

DEPARTMENT OF THE INTERIOR, CANADA

Hon. FRANK OLIVER, Minister; W. W. CORY, Deputy Minister

FORESTRY BRANCH—BULLETIN No. 6

R. H. CAMPBELL, Superintendent of Forestry

LIBRARY
AGRICULTURAL COLLEGE
TRURO, N. S.

THE RIDING MOUNTAIN FOREST RESERVE

BY

JAS. R. DICKSON, B.S.A., M.S.F.,

Asst. Inspector of Forest Reserves.

OTTAWA
GOVERNMENT PRINTING BUREAU
1909



EX LIBRIS
UNIVERSITATIS
ALBERTENSIS

Prairie Provinces Collection

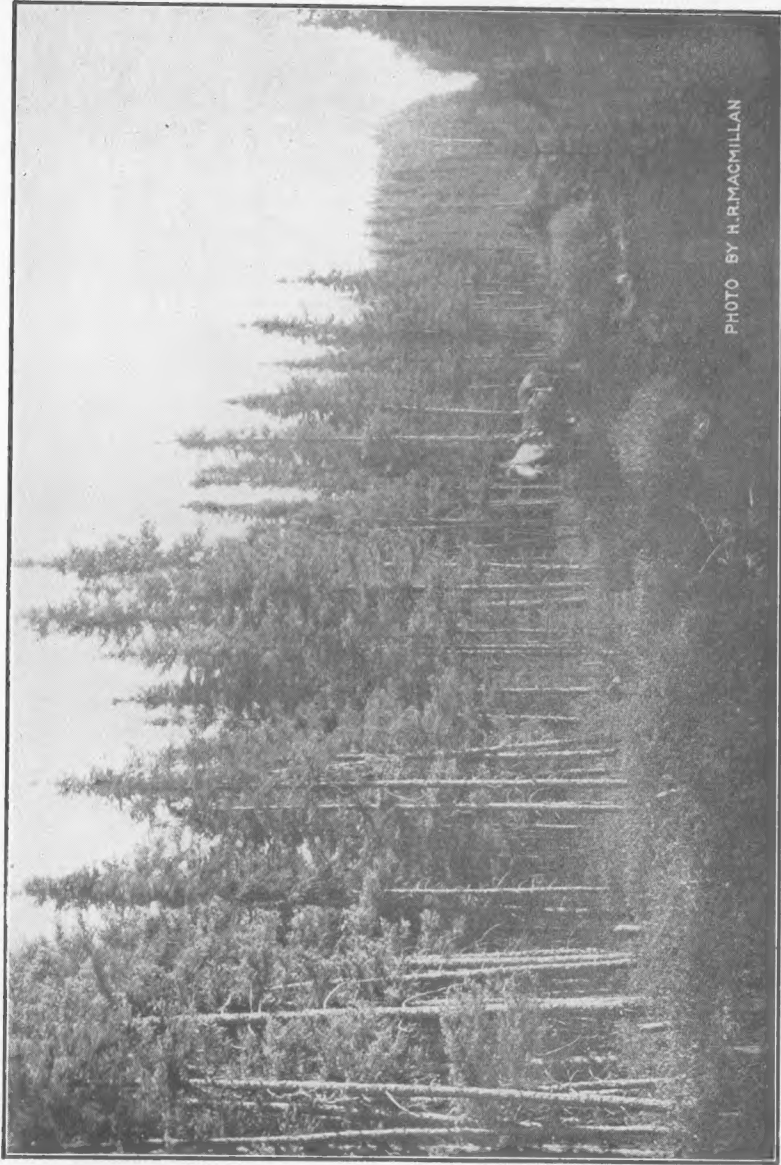


PHOTO BY H. R. MACMILLAN

Mixed Spruce and Jack Pine along Thompson Trail, Township 20, Range 18. Some of it will make ties and small saw-logs.

DEPARTMENT OF THE INTERIOR, CANADA

Hon. FRANK OLIVER, Minister; W. W. CORY, Deputy Minister

FORESTRY BRANCH—BULLETIN No. 6

R. H. CAMPBELL, Superintendent of Forestry



THE RIDING MOUNTAIN FOREST RESERVE

BY

JAS. R. DICKSON, B.S.A., M.S.F.,

Asst. Inspector of Forest Reserves.

OTTAWA

GOVERNMENT PRINTING BUREAU

1909

CONTENTS.

	PAGE.
INTRODUCTION.....	9
FOREST SURVEY OF THE RESERVE—	
Season of 1906.....	9
Season of 1907.....	10
Season of 1908.....	10
Methods of Work.....	10
Summary.....	11
WORKING PLAN REPORT—	
Name, Location and Area.....	11
Topography.....	12
Soils.....	12
Rock.....	12
Climate.....	12
Legal Status of the Forest.....	12
Surrounding Population.....	13
Market.....	13
Timber Permits.....	13
Hay Permits.....	16
General Description of Forest Growth.....	17
Ruling Forest Types.....	17
Poplar Type.....	18
Mixed Type.....	20
Spruce Type.....	21
Jack Pine Type.....	22
Swamp-Muskeg Type.....	22
Forest Enemies—	
Fire.....	23
Methods of Protection.....	24
Disease.....	24
Insects.....	26
Wind.....	27
Frost.....	27
Man.....	27
Study of Species—	
White Spruce.....	28
Black Spruce.....	30
Aspen.....	31
Balm of Gilead.....	33
Jack Pine.....	34
Larch or Tamarack.....	36
Balsam.....	37
Paper Birch.....	37
Utilization of Species.....	38
Lumber.....	38
Spruce.....	38
Poplar.....	39
Other species.....	40
Cordwood.....	40
Other uses.....	40
Game on the Reserve.....	41
Value of the Reserve as a Water Reservoir.....	41
Use of the Reserve as a Pleasure and Health Resort.....	41

ILLUSTRATIONS.

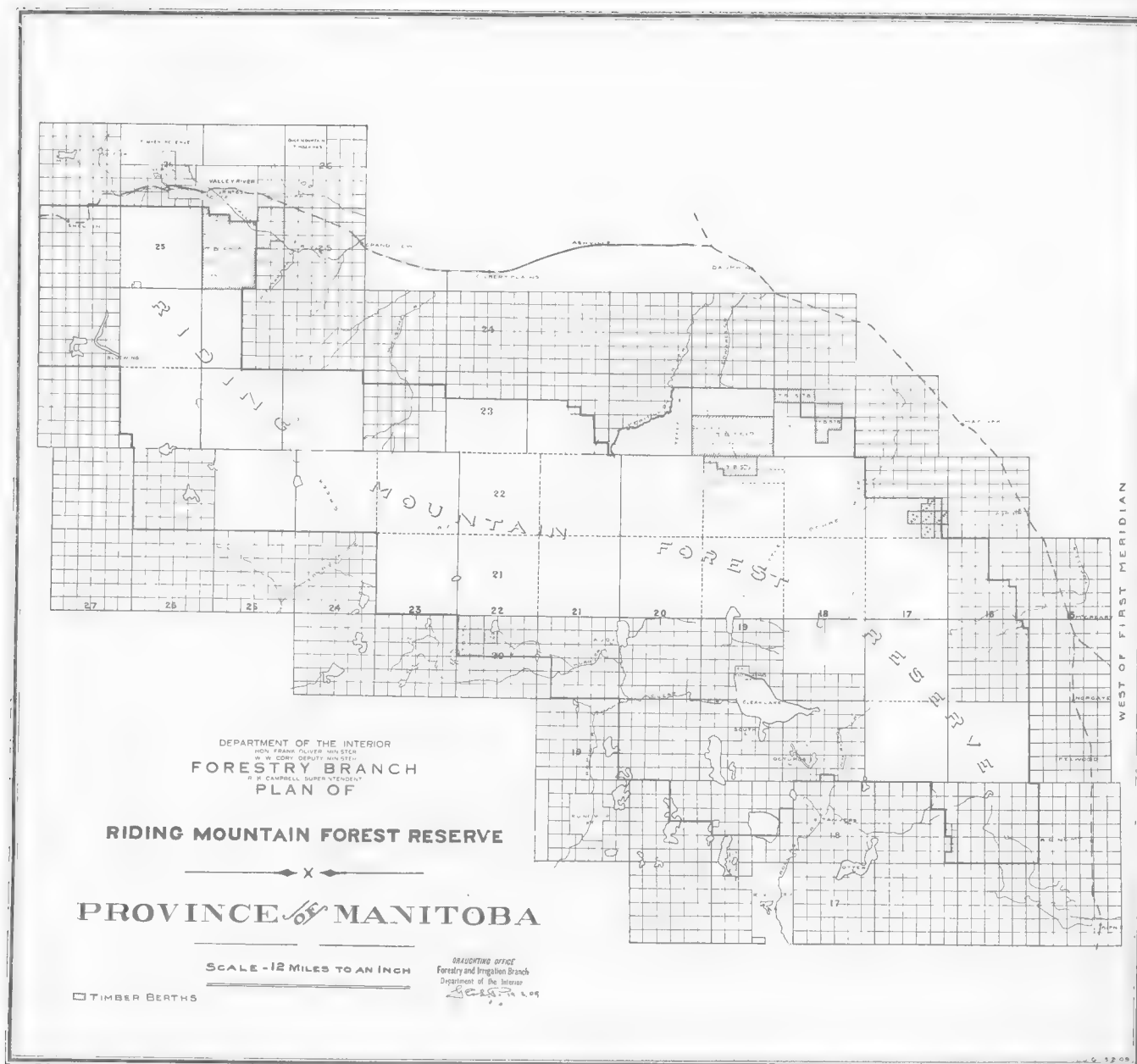
PLATE	I.	Mixed Spruce and Jack Pine along Thompson Trail, Township 20, range 18..	Frontispiece.
PLATE	II.	Party at work surveying trail.....	To face page 10
PLATE	III.	Moving camp.....	" " 10
PLATE	IV.	Typical hay meadow on Little Saskatchewan.....	" " 12
PLATE	V.	Over-mature poplar type.....	" " 19
PLATE	VI.	Mature Aspen killed by ground fire.....	" " 23
PLATE	VII.	Typical park country, the result of past fires.....	" " 24
PLATE	VIII.	Spruce and Larch 'brûlé'.....	" " 24
PLATE	IX.	'Punks' or fruiting bodies of Polyporus (Fomes) igniarius.....	" " 25
PLATE	X.	Typical open grown White Spruce.....	" " 28
PLATE	XI.	Larch and White Spruce Cones.....	" " 28
PLATE	XII.	70-year-old stand of Balm on site of first quality.....	" " 33
PLATE	XIII.	White Birch coppice.....	" " 37
PLATE	XIV.	Sawmill at Shortdale, Man.	" " 39
PLATE	XV.	Balm lumber in pile.....	" " 39
PLATE	XVI.	Camp on Clear Lake.....	" " 42
PLATE	XVII.	Large moose in scrub in valley of Robinson river	" " 42
PLATE	XVIII.	A typical slough, the haunt of wild fowl	" " 42

M A P.

Map showing boundaries of Riding Mountaing Forest Reserve.....	To face page 9
--	----------------

TABLES.

- I. Summary of Receipts from Timber Permits.
- II. Classification of Permits issued on the Reserve as to Products.
- III. Classification of Timber Permits by Years, &c.
- IV. Summary of Hay Permits issued at Dauphin Land Office.
- V. Stand Table showing the number of trees per acre for brûlé type in the west end of the reserve.
- VI. Stand Table showing average number per acre of trees of each diameter class in poplar type.
- VII. Stand Table showing the average number per acre of trees of each diameter class in mixed type.
- VIII. Stand Table showing average number per acre of trees of each diameter class in White Spruce type.
- IX. Stand Table showing the average number per acre of trees of each diameter class in the Jack Pine type.
- X. Stand Table showing average number per acre of trees of each diameter class in Swamp Muskeg type. (Quality I).
- XI. Study of Aspen plots showing the percentage of trees diseased and habits of the fungus *Polyporus (Fomes) igniarius*.
- XII. Decay in Aspen. A study of 660 apparently sound Aspen trees.
- XIII. Decay in Balm. A study of 177 apparently sound Balm trees.
- XIV. Frost Crack in Balm. A study of sample plots to show the prevalence of Frost Crack in Balm.
- XV. White Spruce. Table to show growth in diameter and height (based on age of trees) (Average tree for all sites).
- XVI. White Spruce. Volume Table compiled from measurements of 46 trees.
- XVII. Table showing height and diameter growth in White Spruce reproduction. (Based on measurements of 274 seedlings in good soil for spruce).
- XVIII. Black Spruce. Volume Table (based on measurements of 34 trees).
- XIX. Black Spruce. Table showing growth in diameter and height (based on measurements of 34 trees).
- XX. Aspen. Table showing percentage of bark at different ages.
- XXI. Table showing height and diameter growth in Aspen reproduction. (Compiled from measurements of 272 trees).
- XXII. Aspen. Volume Table. (Based on measurements of 62 trees).
- XXIII. Aspen. Table showing probable future yield.
- XXIV. Balm. Table showing growth in height and diameter. (Computed from measurements of 33 trees).
- XXV. Jack Pine. Table showing total height and clear length on diameter basis. (Based on measurements of 224 trees in a typical Jack Pine stand).
- XXVI. Jack Pine. Table showing growth in diameter on the basis of age. (Compiled from measurements of 50 representative trees).
- XXVII. Jack Pine. Volume Table showing contents of each log in cubic feet. (Logs taken to 4 inches at the top).
- XXVIII. Jack Pine. Volume Table showing contents in board feet (Scribner Rule) of logs 8 feet long. (Logs taken to 6 inches at the top).
- XXIX. Jack Pine. Table showing taper of logs.
- XXX. Larch. Table showing how height and diameter growth of Larch is affected by drainage conditions.
- XXXI. Balsam. Growth in height and diameter, based on age. (Computed from measurements of 28 trees).
- XXXII. Paper Birch. Growth in height and diameter, based on age. (Computed from measurements of 24 trees).
- XXXIII. Paper Birch. Table showing volume in cords per tree.
- XXXIV. Estimate of Saw Material on the Riding Mountain Forest Reserve.
- XXXV. Land classification of the Riding Mountain Forest Reserve.



RIDING MOUNTAIN FOREST RESERVE

The great plains of the Canadian west are becoming more and more closely settled, and coincident with the occupation of these vast wheatlands has arisen a great demand for fuel, lumber, railway ties, fencing material and other wood products of all kinds.

Attention was thus directed to the sources from which supplies to meet such present and future needs must come, and among these sources the Riding Mountains were conspicuous, both from the quantity of timber thereon and because of their situation as the natural supply depot and water reservoir for extensive, fertile and well-watered plains.

By gradual steps a forest reserve of approximately one million acres was delimited and finally set aside, but the severe ravages of fire (more or less the result of destructive lumbering) and the growing proportion of inferior species, with their alarming percentage of fungal and other defects, give the plainest kind of warning that the mere setting aside of a forested area will do little to preserve its supplies. Even the present rate of consumption will soon see the supply vanish unless the administration proceeds to perfect the protective organization, supervise and encourage economic use and introduce enough silviculture to steadily improve the forest yield in quality and quantity.

All this was foreseen by the Federal Government some years ago and the work of obtaining a definite knowledge of prevailing conditions so as to form a secure basis and guide for future action was begun on this reserve in 1906, and carried on to at least approximate completion in 1908. This bulletin undertakes to present in a brief way the gist of this study and some conclusions arising therefrom. The purpose of this bulletin is threefold: to outline the field-work done, to report the conditions found and to suggest tentative lines of management.

FOREST SURVEY OF THE RESERVE.

SEASON OF 1906.

Following up the policy of taking a general inventory of the resources of the Dominion Forest Reserves, initiated in 1905, the Inspector of Reserves detailed a party of ten to continue the work in the Riding Mountains, during the summer of 1906. This party, under the charge of Mr. H. C. Wallin, started from Dauphin on June 1st, and passed south along Shaw's trail through Township 23 into Township 22 of Range 19. Four camps were placed and all the forest within reach of them was sampled by means of valuation survey strips spaced at one-quarter to one-half mile intervals, according to the nature of the timber. From camp III in S. 28, T. 22, R. 19 a party of three pushed south to Clear Lake, some fifteen miles, to reconnoitre the country and find out if the Thompson trail were passable. They found it was not.

The party was therefore forced to move north and west to the Vermilion Valley and pass south across the reserve over the Strathclair trail, covering en route a strip of country from six to ten miles wide. At the junction with the Clear Lake trail in S. 6, T. 20, R. 20, the party moved east 9 miles and from camp IX at the west end of Clear Water Lake, the Ochre and Minnedosa trails, running north and south respectively, were surveyed, and the country adjacent studied and mapped. From a final camp at the eastern extremity of Clear Lake parts of the Thompson, McCreary, Danvers and Cameron trails were surveyed, and strips run from them to cover as much of the country as possible, before the break-up of the survey on September 27. Approximately 337 square miles were covered during the season of 1906, comprising parts of 16 townships. The very wet weather during June and July was a great hindrance, as it kept the trails almost impassable and delayed the work generally.

SEASON OF 1907.

On June 20, 1907, a party under Mr. A. H. D. Ross entered the reserve west of McCreary, and worked south-west over the McCreary trail toward Clear Lake. Upon reaching the fourth camp in S. 8, T. 20, R. 17, further progress was found impossible owing to the wetness of the season. The party was forced, therefore, to come out and enter the reserve again farther south, losing considerable time. Entering west of Kelwood, the party placed four camps in T. 19, R. 16, reaching also parts of Townships 18 and 20 of Range 16, and Townships 18 and 19 of Range 17.

One hundred and seventy square miles were covered, embracing parts of 8 townships.

Field work was carried on in the face of many difficulties. The summer of 1907 in the Dauphin district was the wettest in the memory of the oldest inhabitant, making the trails well-nigh impassable, and keeping the men in camp fully one-third of the time. The country worked over was most difficult. Where not hilly and dense with underbrush, it was either muskeg or jack pine brûlé, covered with down timber. To transport the outfit the party was compelled to cut some 15 miles of wagon road, and build several bridges. The mosquitoes were still quite as numerous and annoying in mid September as earlier in the season.

SEASON OF 1908.

On June 12, 1908, a party of eleven, in charge of Mr. J. R. Dickson, started in at the village of Ochre River and proceeded along the Ochre trail to Clear Lake, about forty miles, working the adjacent country on both sides. From Clear Lake the lack of interior trails forced the party to pass west by way of the Galician settlements, bordering the south side of the reserve, but sub-camps were thrown in as the party moved along. On entering the Birdtail valley in September the party went north-west, passing over the height of land and along the Russell, Fisher and Gambler trails, conducting thus a rapid reconnaissance survey of almost the entire west end. The area covered in 1908 can, from the nature of the survey, be given only approximately. Thirty townships were traversed in whole or in part, 660 square miles being mapped, studied and the important trails surveyed. Of this area 115 sections lay in the east end and 545 in the west. As in previous years the objects of the survey were to find out the quantity of timber remaining, to map the existing trails, water-courses and forest types, to study the rate of growth of the various species and the possibility of introducing better species, to estimate the present use and abuse of the forest by millmen and settlers, and to consider means for reducing the ravages by fire and other enemies.

All this is necessary in order to formulate even a simple plan of management. Inasmuch as the reserve is a mere wreck of a normal forest, an expensive survey and timber valuation with a view to immediate exploitation was not considered necessary. Hence the object of all survey work already done thereon was simply to acquire a basis of knowledge for governing present use, organizing efficient protection, and otherwise ensuring the future welfare and permanence of the forest.

METHODS OF WORK.

Wherever the quantity and the quality of the standing timber was such as to justify the time and expense entailed, valuation survey methods were followed. Parallel sample strips half a chain wide were taken every quarter or every half mile, from two to four per cent of the total timbered area being thus measured. In the homogeneous poplar stands which prevail in most parts of the reserve a close estimate can be made on this basis. The first work done at each camp was the surveying and mapping of the important trails and streams; then in timber, regular four-man parties were sent out on compass lines to tally all trees over four inches in diameter on their strips, to map the forest types, and gather all other data called for (e. g., a description of the flora, the



Party at work surveying trail with chain and compass (east side of Lake Audy).



Moving Camp, vicinity of Clear Lake.

underbrush, the reproduction, damage from fire or other causes, and the soil and drainage conditions). Owing to the dense underbrush, twelve acres proved a good average day's work. Stem-analysis parties were sent out as occasion offered.

SUMMARY.

As a result of the three season's work on the reserve, 1,170 square miles have been studied and surveyed with that degree of completeness which the value of the timber or other conditions appeared to justify. There are left some 365 square miles scattered through the reserve upon which forest survey work has not been done. On at least half of this area, however, a very fair knowledge of the prevailing conditions has been gained. Regarding those portions of territory left more or less untouched by previous surveys, it will probably be best not to send any special party to complete them, but rather to wait until a more specific demand arises for detailed information.

WORKING PLAN REPORT.

The purpose of a Working Plan Report for a forested area is to set out clearly, yet briefly, all the facts and conditions affecting the timber tract that are likely in any way to prove useful or necessary in the work of laying out plans for its future management.

Name, Location and Area.

This area, known as the Riding Mountain Dominion Forest Reserve, comprises 1,535 square miles of rough mountainous country in West Central Manitoba. As shown on the map, it extends north and south from townships 18 to 25 and between Ranges 16 and 27 inclusive. It is the largest of the federal reserves, and is situated in the midst of prosperous communities, whose demands for its products has already reached large proportions.

As constituted by the Dominion Forest Reserves Act of 1906 (6 Ed. VII cap. 14), it consists of the following townships: township 18, range 16; township 19, ranges 16, 17, 19 and 20; township 20, ranges 17, 18, 19 and 20; township 21, ranges 17, 18, 19, 20, 21, 22 and 23; township 22, ranges 18, 19, 20, 21, 22, 23, 24, 25 and 26; township 23, ranges 24 and 25; township 24, ranges 26 and 27; township 25, ranges 26 and 27; the following sections in township 18, range 17, namely, sections 1, 13, 24, 25, 26, 35, and 36, and the east half of section 12; in township 18, range 19, sections 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 and 36; the north-east quarter of township 18, range 20; in township 20, range 21, sections 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 and 36; the north half of township 20, range 22; all of township 23, range 26, except section 6; in township 25, range 25, sections 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 20, 21, 22, 27, 28, 29, 30 and those parts of sections 31, 32 and 33 not included in the Gambler Indian Reserve; the west half of township 24, range 25; in township 23, range 23, the following sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30; in township 23, range 22, sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24; in township 23, range 21, sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21 and the south half of 22; all of that portion of township 23, range 20, lying south and east of the Vermilion River, excepting sections 36 and that part of section 35 lying east of the said river; in township 23, range 19, sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30; in township 23, range 18, sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 29 and 30; in township 22, range 17, sections 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, and the west half of sections 1, 12 and 13; in township 21, range 16, sections 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 21, 28, 29, 30, 31, 32, 33, and the south half and northwest quarter of section 14; all of township 20, range 16, except the north-east quarter of section 36; all of township 19, range 18, except the south-west quarter and the west half of the southeast quarter of section 3, and the east half of the south-east quarter of section 4; all west of the first principal meridian.

Topography.

In a general way, the land surface may be said to consist of two rolling plateaus. The first of these, known as the "Lower Plateau", has a relative altitude of 300 to 400 feet above the surrounding plains, and the upper one is at a height of 800 to 1,000 feet above these plains. The absolute altitude of the upper plateau is 1,900 to 2,100 feet.

The upper plateau comprises about nine-tenths of the whole area and is divided by low watersheds into a number of drainage basins in which rise the headwaters of several of the most important rivers in Manitoba. About twenty per cent of this plateau consist of swamps and muskegs, which act as great sponges, feeding the streams throughout the year. The hills rise abrupt and precipitous from the prairie on the east and slope gradually away to the south and west. This reserve has a great number of smaller lakes scattered through it, and several fairly large ones, the largest being Clear Lake, situated near the highest point of the range.

Soils.

As the entire range of hills is of purely glacial origin, the soils are necessarily very deep and extend from gravels and light sandy loams to the heaviest bog and boulder clays. In some localities the well decomposed humus from poplar and spruce litter darkens the soil to a depth of two feet. On the other hand, on the main trails and in the west end generally, where frequent fires have swept through, there is little or no humus. Frequent bogs on hill sides or tops attest the impermeable nature of the underclays. In the typical jack pine areas, comprising probably five per cent of the upper plateau, the soil is a light sandy loam and is too dry for agricultural purposes.

Rock.

The only outcropping rock is shale, which appears along the deep ravines. A large proportion, however, of the heavy clay soils are thickly sown with granite and diorite boulders, which, no matter how level or rich such soils may be, render them quite unsuitable for farming purposes, with the possible exception of grazing. These boulder clays, however, are exactly suited to spruce and the dry sandy soils to red, Scotch or jack pines.

Climate.

The climate is extreme, though not so markedly so as that of the surrounding plains, for, although the winter temperatures are quite as severe—going to 40° below zero—the summers are relatively much cooler, owing to the altitude, the cooling influence of the forest and the heavy rainfall of June and July. The mean annual precipitation is 22 inches. On the upper plateau frost may occur every month in the year, just as in the Adirondacks, for instance. But these occasional light frosts between the first of June and the end of September have little or no effect on the growing season for timber. The very long days, giving daylight from 3 A.M. till 10 P.M., make growth surprisingly rapid and the season increment quite satisfactory.

There is, of course, plenty of snow for winter logging, though less, as a rule, than in the Ottawa Valley. The level open muskegs being frozen and safe for travel, it is easy to pick out excellent roads with low grades.

Legal Status of the Forest.

Title to all the land in the Dominion Forest Reserve is vested, of course, in the people of Canada, and the reserve is free from all taxation. Thanks to the good work done in 1908, all squatters have been finally removed, and, save for a half-section in S. 6, T. 20, R. 20, which is held in fee simple by one of the rangers, there are no interior hold-

PLATE IV.



[*Photo by H. R. MacMillan.*
Typical Hay-meadow on the Little Saskatchewan, Township 20, Range 20.

ings in the reserve. Both dominion and provincial fire laws apply to the reserve, and no vested rights or privileges have been permitted to arise through use or custom, so that, on the whole, the opportunity for forest management is an excellent one.

Surrounding Population.

The general occupation is farming or ranching. The towns are small and are supply depots rather than manufacturing centres. There are no minerals nor coal supplies in this land district, so that outside of a little lumbering in the winter season agriculture is the one great wealth-producing industry. Within the fifty-mile limit from the boundaries of the Riding Mountain Reserve there is a most heterogeneous population. In various more or less compact settlements are racial communities of French, Germans, Galicians and Scandinavians, while connecting all, as it were, in a common matrix is the great body of settlers from the British Isles and Eastern Canada.

Among certain of the foreign element there is naturally a great amount of ignorance and indifference to overcome. They have neither patriotism nor intelligence enough to consider the future. This fact, the more regrettable in that such settlers are clustered about the reserve, makes administration, and more especially protection, vastly more difficult.

In the English-speaking community there is a general and growing appreciation of what the reserve does and may stand for. They will be quick to recognize and approve all common-sense measures looking toward its greater utility and improvement, and this spirit of sympathetic co-operation should be developed to the utmost.

Market.

From the nature of the merchantable timber the market will be local and confined to the farmers and the people living in the small towns. What little commercially valuable spruce there is will all be required by the needs of the homesteader and settler. A study of the market situation was made in October, 1908, when several of the prominent lumbermen of the district were interviewed. They cut only spruce and some larch, there being absolutely no market for poplar in commercial quantities. Except that used locally, the product of their mills is all shipped west to Kamsack and other prairie towns, none going to Winnipeg.

A report on markets and lumbering was made as a result of the above conditions, which will be referred to later in this enquiry under the head of "Utilization of Species." (See page 38.)

Timber Permits.

Of the four timber reserves in the Dauphin land district the Riding Mountain is much the most useful to the settlers at present.

During the past four winters the relative proportion of permits granted has been as follows :

Porcupine Reserve.....	1.0 %
Lake Manitoba	1.5 %
Duck Mountain.....	7.5 %
Riding Mountain.....	90.0 %

Of the total permits issued at Dauphin during this period on all the vacant Dominion lands, an average of sixty-seven per cent has been from these four reserves, and from the Riding Mountains alone sixty per cent.

Two classifications of the timber permits issued on the Riding Mountain Reserve during the past three years are given below. That based on "kind of permit" shows that sawn lumber is far and away the most important class. The classification on a

locality basis may be useful in showing what ranger districts are most important, and what settlements are drawing most heavily on the supplies from the reserve. As yet nearly all the permits are confined to the outside townships of the reserve. Only five per cent, for instance, have come from the six interior townships of the east end, viz.:—

Township 20 in Ranges 17, 18 and 19.

Township 21 in Ranges 18, 19 and 20.

Nearly all timber permits are issued in January, February and March, the revenue for the past three years at the Dauphin office being given below :

TABLE I.—SUMMARY OF RECEIPTS FROM TIMBER PERMITS.

Month.	1905-1906.	1906-1907.	1907-1908.
	\$ cts.	\$ cts.	\$ cts.
July.....	4 25		
August.....	1 50		121 00
September.....	1 25		8 00
October.....	8 50		19 00
November.....	276 80	10 75	107 00
December.....	1,225 50	85 40	726 75
January.....	2,369 00	750 93	1,842 21
February.....	2,269 00	1,477 36	1,943 27
March.....	1,459 00	891 40	1,010 80
April.....	43 75	115 42	81 60
May.....	93 00	110 25	21 00
June.....	0 75	0 50	4 00
Totals.....	7,752 30	3,442 01	5,884 63

CLASSIFICATION OF TIMBER PERMITS.

A. As to *Product* :

Five main classes of permits are considered. These are as follows :—

<i>Class.</i>	<i>Unit.</i>
1. Sawn Lumber.....	Board foot.
2. Cordwood.....	Cord.
3. Building logs.....	Lineal foot.
4. Poles and Rails.....	Piece.
5. Posts.....	Piece.

(See Table II).

B. As to *Locality* :

For this classification the reserve may be divided into four main districts, as follows :—

- “ West ”—All Townships in Ranges 24 to 27, inclusive ;
- “ Middle North ”—Townships 22 and 23 in Ranges 18 to 23 inclusive ;
- “ Middle South ”—All Townships south of 22 in Ranges 18 to 23, inclusive ;
- “ East ”—All Townships in Ranges 16 to 17.

(See Table III).

TABLE II.—CLASSIFICATION OF PERMITS ISSUED ON THE RESERVE AS TO PRODUCTS.

For the year July 1, 1905, to June 30, 1906.

Class.	Total number of permits.	Total amount for given year.	Amount in average permit.	Approximate percentage of total timber permits for given year.	Per cent of permittees calling for each class.
Sawn lumber..... b. ft.	1,020	7,782,000	7,629	77 p. c.	99 p. c.
Cordwood cords	84	1,199	14.3	6 p. c.	8 p. c.
Posts..... pieces	102	44,360	435	8 p. c.	10 p. c.
Poles and rails..... "	64	52,695	823	5 p. c.	6 p. c.
Building logs..... l. ft.	56	54,770	978	4 p. c.	5 p. c.

The quantity removed for which no permits were issued is of course unknown.

For the year July 1, 1906, to June 30, 1907.

Sawn lumber b. ft.	208	1,225,000	5,889	84 p. c.	95 p. c.
Cordwood cords	29	910	31.4	12 p. c.	13 p. c.
Posts..... pieces	5	2,400	480	2 p. c.	2.5 p. c.
Poles and rails. "	3	2,300	786	1 p. c.	1.5 p. c.
Building logs l. ft.	3	3,500	1,166	1 p. c.	1.5 p. c.

For the year July 1, 1907, to June 30, 1908.

Sawn lumber b. ft.	506	2,931,250	5,793	74 p. c.	90 p. c.
Cordwood cords	60	1,305	21.7	9 p. c.	11 p. c.
Posts..... pieces	66	26,400	400	9 p. c.	12 p. c.
Poles and rails. "	30	36,500	1,217	4.5 p. c.	5 p. c.
Building logs..... l. ft.	22	19,100	868	3.5 p. c.	4 p. c.

For the average year.

Sawn lumber..... b. ft.	578	3,979,410	6,437	78 p. c.	95 p. c.
Cordwood cords	58	1,138	22.5	8 p. c.	11 p. c.
Posts pieces	58	24,390	438	8 p. c.	8 p. c.
Poles and rails..... "	32	30,498	942	4 p. c.	3.4 p. c.
Building logs l. ft.	27	25,790	1,064	4 p. c.	3.5 p. c.

Approximate use for all purposes : 5,000,000 board feet per year.

TABLE III.—TIMBER PERMITS IN EACH LOCALITY.

(The following table covers the past three years.)

DISTRICT.	JULY 1, 1905, TO JUNE 30, 1906.			JULY 1, 1906, TO JUNE 30, 1907.			JULY 1, 1907, TO JUNE 30, 1908.		
	No. of Permits.	Per-centage of Total for Reserve	Most Important Town-ships.	No. of Permits.	Per-centage of Total for Reserve	Most Important Town-ships.	No. of Permits	Per-centage of Total for Reserve	Most Important Town-ships.
West.....	412	40%	25-26 (84%)	80	37%	25 26 (73%)	121	21%	25-26 (73%)
Middle north.	162	16%	23-23 23-22	34	16%	No out-standing township.	107	19%	Several on 15-20
Middle south.	139	13%	20-19 21-21	76	35%	19-20 (16%)	204	36%	21-21 (35%)
East.	315	31%	18-16 21-16	27	12%	No out-standing township.	130	22%	21-16 (36%)
Total ..	1,028	.....	.....	217	.....	.....	562	.....	.....

An estimate was made recently by three of the rangers, of the quantity of timber removed from the reserve for which no permits are issued and the result shows that a large amount of material is being thus illegally cut—from five to ten per cent in excess of the quantity allowed by the permits in case of poles, rails, posts and sawn lumber, from fifty to one hundred per cent in the case of cordwood. The relatively high dues, combined with the hard times of the past two years, no doubt account for this. It is true that most of this material goes to benefit the local settler; but why can he not enjoy it without breaking the law? To solve the problem and place the use of all reserve products on a smooth-running business basis should be the first duty of the new office of reserve administration in Dauphin. That done, there will be very little more friction as the result of illegal cutting and consequent seizure.

HAY PERMITS.

Owing to the fact that the regulations do not make it obligatory to take out a permit to cut hay, it is certain that a very large amount of hay has been and is being cut in this land district of which no record is available. From the data at hand it appears that up to the present only a small part of the total cut has come off the four reserves, and all of this has come from the Riding Mountain Reserve, except 20 tons cut in 1908 on the Duck Mountains.

So far as revenue goes, however, the whole matter of hay usage is a trifle in the total of the reserve finances, but if permits were compulsory no doubt some increase would follow. The following table gives a brief summary of the hay output in recent years, according to the permits issued.

TABLE IV.—SUMMARY OF HAY PERMITS ISSUED BY DAUPHIN LAND OFFICE.

Year.	Total tons cut on Dominion Lands in Dauphin District.	Tons cut on Riding Mountain Reserve.	Per cent of total cut on Riding Mountain Reserve.	Hay permit revenue on Riding Mountain Reserve.
			p. c.	\$ cts.
1901.	7,981	135	1·7	15 25
1903.	1,210	68	5·0	9 70
1904.	2,725	80	3·0	12 10
1906.	2,450	245	10·0	31 50
1907.	4,465	455	9·7	54 50
1908.	4,790	405	8·0	35 00

GENERAL DESCRIPTION OF FOREST GROWTH.

The forest of the lower plateau consists for the most part of aspen and balm poplar, with, in places, a large inclusion of paper birch, and in the coulees and ravines a scattering of elm, oak, ash and maple. On the upper plateau poplar is still the predominant genus, but the stand is much more mixed in character, more or less coniferous growth is everywhere present and considerable areas are given over almost wholly to spruce and balsam, or, in the drier sandy parts, to jack pine.

Owing to the slashed, diseased and burnt-over condition of the stands of timber on this reserve, the relation between growth and decay is a very difficult matter to estimate. In general it can be said that west of the Strathclair trail (where 60 per cent of the area carries young stock) growth is greater, that east of this trail decay is greater, and, on the whole, that at present growth exceeds decay by at least 25,000 cords per annum.

THE RULING FOREST TYPES.

Every good farmer knows that certain parts of his farm are better adapted than other parts to the producing of particular crops. This may be due to the slope, or more often to a soil variation; but, whatever the cause, he is likely to regard each section of this type as a staple unit in his scheme of management, and treat it in a definite uniform way. Now timber is simply a slow-growing crop and the forester, if you will, is a tree-farmer; and the natural laws acting in the forest, as on the farm, likewise determine his crop unit—namely, a “forest type”. There are at least two main ways of classifying these:

1. As natural types and fire types.
2. As permanent and temporary types.

The latter is best because less arbitrary; its conception gives a rational basis for sound silvicultural methods.

A *temporary type* may be best named after the species of tree which is present in largest numbers. It is simply some intermediate stage in a long process of natural evolution, the end or “climax” type of which is a *permanent type*. In the case of burned-over areas—the so-called “brûlés”—fire simply breaks this chain and causes the process to begin again at the first.

A *permanent type*, therefore, is the ultimate creation of all the growth factors of a locality. If one factor outweighs all the others in relative importance, it is said to control the type. On the Riding Mountains the soil is such a factor and determines three main permanent types.

1. That on the clays and loams (white spruce).
2. That on the sands (jack pine).
3. That on the muskegs (larch and black spruce).

The last, however, is due to poor drainage rather than to soil variation. Examples of all these occur in different parts of the reserve, but cover at present only a minor area. To describe present conditions, therefore, it is necessary to include at least two of the more important intermediate types, namely, "Poplar" and "Mixed".

Fire-swept forest land or brûlé, is, properly speaking, not a type but merely a condition, because produced through accident and not by natural growth. It may have been burned over so often as to have become a prairie, or, on the other hand, only a single fire may have run through and killed the timber, and between the extremes every possible condition of reproduction may occur, and does occur, in the Riding Mountains.

TABLE V.—STAND TABLE SHOWING THE NUMBER OF TREES PER ACRE IN BRÛLÉ TYPE IN THE WEST END OF THE RESERVE.

(Compiled from 78 sample plots, area of each $\frac{1}{16}$ ac.)

	Aspen.	Balm.	Birch.	Total.
Number of Trees per acre	1,644	583	24	2,251
Per cent of total stand	73 %	26 %	1 %	100 %

The above table gives the average of young stands in which the trees cover more than 30 per cent of the ground. This is the case on 66 per cent of the total area west of the Strathclair trail. The average diameter of this young growing stock is 1 to 3 inches at breast-height, the average height 17 ft. and the average age 17 years.

About 70 per cent of the west half of the reserve is brûlé—the result of the dry seasons and large fires of the eighties—but, as there have been no wide spread fires in recent years, wherever drainage is adequate fully three-quarters of this denuded land now carries more or less thrifty, ten to twenty foot poplar reproduction of varying density. Throughout the reserve, in the poorly drained parts burned over, there is a fairly satisfactory larch and black spruce reproduction. On the dry sandy soils there are many promising young stands of jack pine but there is practically no white spruce reproduction, even where plenty of seed trees were left after the fire. The young poplar grows rapidly, and if the west end of the reserve can only be protected from fire for the next twenty years the resulting forest will furnish very large quantities of material for fuel and other purposes.

THE POPLAR TYPE.

This is the first temporary type following brûlé on suitable soils, and occurs wherever there are stands of poplar over 60 per cent pure. It is confined to the more or less well-drained loams, and the composition runs from pure balm in the wetter parts to pure aspen on the uplands. There is a sprinkling of birch, oak, ash, elm and white spruce. The density of the stand is very variable, and with it varies directly the quality of the timber. In open stands where the ground is less than half occupied, the trees are limby and only forty to fifty feet high; but where they stand close they rise to between sixty and eighty feet in height, taper but slightly and are free from limbs. There is no definite size or age limit below which poplar of either variety can be called sound, and above which it may be called unsound. Occasional trees reach thirty to thirty-six inches diameter breast-high, but such are always badly diseased. The average size of mature sound poplar over whole stands is about ten to twelve inches d. bh., with an average yield per acre of one to two thousand feet board measure. The forest floor consists of dead leaves and vines, overlying two to four inches of black well-decomposed vegetable mould. The ground cover under good timber is a rather sparse growth of violets (*Viola*), sarsaparilla (*Aralia*), strawberry (*Fragaria*) and other wood plants; in more open woods it is usually a mat of peavine (*Lathyrus*) while in the scattered timber of semi-prairie lands on the upper plateau a rich profusion of mints, asters, golden rods and



Over-Mature Poplar type. The remaining timber will make some firewood

other Compositae flourish among the grass. The underbrush consists of a more or less dense mass of hazel (Corylus), cranberry (Viburnum), wild plum and cherry (Prunus), dogwood (Cornus), and many other smaller shrubs such as currant (Ribes), raspberry (Rubus) and buckthorn (Rhamnus). It is so closely matted together over large areas as to make progress through it very slow and difficult.

The poplar type naturally divides into several sub-types, depending on the age and condition of the stands. Thus:—

1. Pole Stand.
2. Semi-Mature Stand.
3. Mature Stand.
4. Over-Mature Stand.

These terms almost explain themselves. The first refers to a thrifty young stand of trees four to eight inches in diameter. The other three terms are more indefinite in their application because based only on the apparent maturity of the timber, or, in other words, its relative value to the lumberman. In a "semi-mature" forest some of the trees are ready to cut, but a large percentage are still too small. A mature stand, of course, is just ready for the axe; but over this stage, decay and deterioration from the attacks of fungi, insects and wind is very rapid, making it *over-mature*, and hence all but useless from the lumberman's standpoint, in ten to twenty years' time. This type is an important one in the east end of the reserve, there being, as shown on the map, a large number of sections now carrying mature to over-mature stands of poplar which should be removed to make way for a new growth, as the producing power of soils so occupied is lying more or less idle, so constituting an unproductive capital.

TABLE VI.—STAND TABLE, SHOWING AVERAGE NUMBER PER ACRE OF TREES OF EACH DIAMETER CLASS IN POPLAR TYPE.

(Based on measurement of 75 acres).

Diameter Breast-high Outside Bark.	NUMBER OF TREES PER ACRE. TOTAL 145'4.						
	Aspen.	Balm.	Birch.	Oak.	Elm.	Ash.	Spruce.
Inches.							
4.....	2·4	1·0	1·8	0·8	0·2	0·4	.....
5.....	2·6	1·3	1·6	0·6	.....	0·2	0·1
6.....	5·6	2·0	2·0	0·3	0·3	0·2	.....
7.....	10·5	3·1	2·5	0·3	0·1	0·1	0·1
8.....	14·5	4·2	2·0	.....	.....	.....	.....
9.....	14·5	4·7	1·7	.....	.....	.....	.....
10.....	15·6	4·3	1·5	.....	.....	.....	.....
11.....	10·6	4·0	0·5	.....	.....	.....	.....
12.....	9·0	3·0	.....	.....	.....	.....	.....
13.....	5·3	1·4	.....	.....	.....	.....	.....
14.....	3·1	1·4	.....	.....	.....	.....	.....
15.....	1·5	0·8	.....	.....	.....	.....	.....
16.....	1·0	0·4	.....	.....	.....	.....	.....
17.....	0·3	0·15	.....	.....	.....	.....	.....
Total	96·5	31·7	13·6	2·0	0·5	0·9	0·2
Above 8 in.....	75·0	24·0	5·7	.....	.....	.....	.....
Merchantable above 10 in...	46·4	15·1	2·0	.....	.....	.....	.....
Percentage of total for each species.....	66·5	21·8	9·3	1·4	0·3	0·6	0·1
Percentage Merchantable (based on total no. of trees).....	31·9	10·4	1·4	.....	.....	.....	.....

THE MIXED TYPE.

This type is purely temporary and signifies only that two or more species are growing in more or less equal and intimate mixture over the given area. It is merely an intermediate step between the simple primitive light-demanding poplar type and the final, or climax, shade-enduring spruce type; that is to say, where soil and climate conditions are nearly uniform over an area, as in the Riding Mountains, the species which finally wins out in the fight for existence and permanently establishes itself is that one which can endure at all stages of its life-history the greater amount of shading. Hence, even where birch by greater tolerance or ability to exist under shade has killed out the poplar in mixture, it must itself in the end give way to the all-conquering spruce, and, therefore, in favouring spruce in the future management the forester is working with, and not against, the laws of nature—an important and significant fact.

This mixed type is perhaps the most important one in the east end as regard gross yield and area, covering, for instance, forty-four per cent of the territory reached from the Ochre trail in 1908. It is, however, characterized almost everywhere by very open limby stands, yielding practically no timber of commercial value except as firewood or rough building stuff of small dimensions. In the park country of the upper plateau which falls under this type, ground fires are rather frequent and in consequence the prairie is slowly enlarging its area.

TABLE VII.—STAND TABLE SHOWING THE AVERAGE NUMBER PER ACRE OF TREES OF EACH DIAMETER CLASS IN MIXED TYPE.

(Based on measurement of 75 acres).

Diameter Breast-high Outside Bark.	NUMBER OF TREES PER ACRE. TOTAL 154.5.								
	Aspen.	Balm.	Birch.	Spruce.	Balsam.	Oak.	Ash.	Elm.	Larch.
Inches.									
4.....	1.8	0.9	6.1	2.1	2.1	0.6	0.2	0.2	0.2
5.....	1.4	1.3	8.4	2.9	2.0	0.3	0.2	0.2	0.4
6.....	2.4	1.1	9.5	3.3	2.0	0.1	0.3	0.2	0.4
7.....	3.7	2.3	8.2	3.7	1.0	0.1	.....	0.2	0.4
8.....	4.4	2.3	6.1	4.2	1.4	.....	.....	.....	0.5
9.....	4.7	2.4	3.7	3.7	0.8	.....	.....	.....	0.3
10.....	5.5	2.4	2.5	3.0	1.0	.....	.....	.....	0.4
11.....	5.0	1.7	1.4	2.0	0.8	.....	.....	.....	0.3
12.....	4.7	1.0	1.0	2.1	0.4	.....	.....	.....	0.2
13.....	1.5	1.0	0.5	1.4	0.2	.....	.....	.....	0.1
14.....	1.6	0.8	0.1	1.3	0.1	.....	.....	.....	.....
15.....	0.8	0.5	0.9	.....	.....	.....	.....	.....	.....
16.....	0.5	0.1	0.6	.....	.....	.....	.....	.....	.....
17.....	0.3	.....	.....	0.4	.....	.....	.....	.....	.....
18.....	0.2	.....	.....	0.4	.....	.....	.....	.....	.....
19.....	0.1	.....	.....	0.3	.....	.....	.....	.....	.....
20 in. and over.....	.....	.....	.....	0.8	.....	.....	.....	.....	.....
Total.....	38.6	17.8	49.0	31.6	11.8	1.1	0.6	0.9	3.2
8 in. and over.....	29.3	12.2	16.8	19.6	4.7	.....	.....	.....	.....
Merchantable above 10 in.....	20.2	7.5	7.0	11.7	2.5	.....	.....	.....	1.0
Percentage of total for each species.....	24.3	11.5	32.6	20.4	7.6	0.7	0.3	0.5	2.0
Percentage merchantable (based on total no.)....	13.07	4.8	4.5	7.6	1.6	.....	.....	.....	.....

THE SPRUCE TYPE.

There is no question that this type is in the future destined to be the most important of all. White spruce is the valuable tree of the region, and 60 per cent of the reserve, including all the lands now under poplar and other hard woods, is well suited to its growth. This reserve is right in the optimum belt for white spruce, and, though at present this species covers, unfortunately, only a small percentage of its area in close or pure stand and shows only slow and discouraging progress in regeneration, yet there should be no hesitation in proceeding "to rebuild the house", even if considerable expense is involved in the way of sowing and planting. While there are in a number of places areas of several square miles under this type, it is upon the whole much segregated; small areas of a few acres in extent are scattered everywhere among the poplar. This is just another proof that the permanent type for all the reserve is coniferous; the aspen has come in as the result of fire openings in the once solid spruce forest.

On portions of this spruce type the stand is so dense that nothing grows beneath. The survey sheets gave as many as 750 trees per acre between four and eight inches in diameter. Of course under such timber there is no reproduction, but wherever logging operations have opened up the stand the growth of young spruce is quite satisfactory. At least half of the good spruce still left in the reserve is standing on timber limits, and will be cut by 1912. After protection from fire, the rapid extension of this spruce type is the most pressing need of the reserve, and one of the first steps to this end is to save from the axe, if possible, the remaining spruce seed-trees still sprinkled over large areas. They represent the only hope for natural regeneration.

TABLE VIII.—STAND TABLE SHOWING AVERAGE NUMBER PER ACRE OF TREES OF EACH DIAMETER CLASS IN WHITE SPRUCE TYPE.

(Based on measurement of 50 acres).

Diameter Breast-high Outside Bark.	NUMBER OF TREES PER ACRE (TOTAL 241.66).						
	Aspen.	Balm.	Birch.	White Spruce.	Balsam.	Larch.	Black Spruce.
Inches.							
4.....	0.9	2.1	1.5	17.9	1.3	0.7	0.5
5.....	1.9	2.0	1.4	17.7	1.5	0.6	0.3
6.....	4.8	2.8	2.0	18.8	1.4	2.5	0.1
7.....	6.5	2.9	1.6	22.8	1.1	2.0	0.5
8.....	7.1	3.0	1.3	18.3	1.3	1.3	0.1
9.....	7.4	2.8	1.2	13.3	0.6	0.9	0.06
10.....	5.2	2.7	1.6	10.1	0.3	0.9	0.02
11.....	3.5	1.9	0.7	6.3	0.2	0.4	.....
12.....	2.4	1.5	0.6	2.5	0.3	0.5	.....
13.....	1.3	0.7	0.4	3.1	0.1	0.3	.....
14.....	0.8	0.5	0.4	2.5	0.1	0.1	.....
15.....	0.5	0.5	0.2	1.9	0.1	0.04	.....
16.....	0.3	0.2	0.2	1.3	0.1	.....	.....
17.....	0.1	0.2	0.1	0.9	.....	0.02	.....
18.....	0.1	0.1	0.1	1.0	.....	.....	.....
19.....	0.1	0.1	0.1	0.5	.....	.....	.....
20 in. and over.....	0.1	0.1	0.02	2.0	.....	.....	.....
Total.....	43.0	24.1	13.42	140.9	8.4	10.26	1.58
Merchantable 10 in. and above.....	14.4	8.5	4.42	32.1	1.2	2.26	.....
Percentage of total for each species.....	17.8	10.0	5.5	58.3	3.5	4.2	0.6
Percentage merchantable (based on total no.).....	5.9	3.5	1.8	13.3	0.5	0.9	.....

THE JACK PINE TYPE.

This type is characteristic of the sandy tracts east and north-east of Clear Lake in township 19, ranges 16 and 17, and township 20, ranges 17 and 18. Taken as a whole it is comparatively unimportant, being confined to the nearly level sandy plains that lie along the height of land in these townships. Large portions of this type have been burned over, but now carry another dense young stand, ten to twenty thousand trees per acre, averaging ten feet high. By far the largest single area of virgin pine still standing is the tract covering the north-east quarter of township 19, range 17, and this is being rapidly utilized by the Scandinavians to the south. The fire danger in this type is alarming; in fact, it is difficult to see how the mass of debris and young growth on those great brûlés has so far escaped.

TABLE IX.—STAND TABLE SHOWING THE AVERAGE NUMBER PER ACRE OF TREES OF EACH DIAMETER CLASS IN THE JACK PINE TYPE.

(Based on measurements of 14·5 acres).

Diameter Breast-high. Inches.	No. OF TREES PER ACRE (TOTAL 266·0).					
	Jackpine.	Aspen.	Balm.	Birch.	Larch.	Bl. Spruce.
4.....	8·5					
5.....	12·6					
6.....	22·5					
7.....	25·6					
8.....	31·2					
9.....	28·4					
10.....	21·4					
11.....	17·2	*	*	*	*	*
12.....	15·3					
13.....	6·4					
14.....	5·0					
15.....	3·1					
16.....	1·5					
17.....	·3					
18.....	·1					
19.....	·3					
Total	199·4	13·5	4·3	·3	5·0	43·5
Per cent of total stand	75	5	1·6	0·11	1·9	16·0
Total 10 in. and over.....	130·2					

* These species are in the little swampy depressions dotted all through this type, except the Aspen and Birch which are scattered in the Jack Pine. They are all under 12 in. d.bh. in size. Only the total per acre for each species is given.

THE SWAMP—MUSKEG TYPE.

This type is ubiquitous, appearing everywhere, though as a rule not extending over large contiguous areas. Under this type are included not only the true muskegs, but in addition all such poorly drained areas as exhibit a distinctly swamp vegetation. The range of conditions thus allowed is too great, indeed, to make it a satisfactory crop-unit; but in all pioneer forestry work, much desirable detail must be sacrificed to expediency. The idea is to include in this type the poorly drained, distinctly larch and black spruce lands as opposed to the more or less well-drained white spruce type. There is a great variety in the quality of the type; some of it carries a dense stand of mature larch and black spruce pole timber four to eight inches in diameter, which, owing to its dense fibre, makes the very finest firewood. Considerable areas have already been stripped by the Galicians and others in parts tributary to their settlements, and, as the natural repro-

PLATE VI.



[*Photo by R. D. Craig.*

Mature aspen killed by ground fire, Riding Mountain, September, 1906.

duction on this type is sure and abundant, there is no reason why the balance should not be marketed as fast as convenient. Over the large areas of this type there is only a scattering of stunted larch, hardly worth harvesting, while much of the true muskeg bears only moss and reeds. All around the border of these sphagnum bogs there is excellent larch and black spruce reproduction, which gradually fades out towards the centre. In general, the timber of this type clearly proves the unfavourable conditions by its short, spindly, stunted appearance and extremely slow growth; although on what may be called site I for this type there are in places fair stands of two-log trees running up to 15 inches d. bh. About one-fifth of the whole reserve is embraced in this type.

TABLE X.—STAND TABLE SHOWING THE AVERAGE NUMBER PER ACRE OF TREES OF EACH DIAMETER CLASS IN SWAMP-MUSKEG TYPE (QUALITY I)

(Based on measurements of 50 acres).

Diameter Breast-high Outside Bark.	NUMBER OF TREES PER ACRE (TOTAL 181.6).							
	Black Spruce.	White Spruce.	Larch.	Fir.	Balm.	Aspen.	Birch.	Jack- pine.
Inches.								
4.....	30.7	.....	10.3	2.9	0.3	0.2	.....	.....
5.....	23.7	0.5	11.3	2.0	0.6	0.3	0.2	0.6
6.....	17.7	0.3	9.3	1.6	0.9	0.5	0.2	0.7
7.....	15.2	0.3	6.8	1.0	0.8	0.9	0.1	0.9
8.....	8.4	0.1	3.0	.....	0.5	0.6	0.2	0.3
9.....	5.3	0.2	4.1	0.3	0.6	0.5	0.3	0.2
10.....	2.7	0.2	3.0	0.2	0.6	0.3	0.1	.....
11.....	0.9	1.0	1.6	.....	0.5	0.4	.....	.....
12.....	0.3	0.5	0.6	.....	0.2	0.2	.....	.....
13.....	0.2	0.3	0.5	.....	0.2	0.1	.....	.....
14.....	0.25	0.5	0.25	.....	0.15	.....	.....	.....
Total.....	105.6	3.45	51.0	8.0	5.35	3.8	1.1	2.7
Total, 8 in. and over.....	18.3	.....	13.3	.....	.....	.....	.....	.....
Merchantable, 10 in. and over.....	4.6	2.05	6.2	0.2	1.65	1.0	0.1	.....
Percentage of total for each species	57.8	1.8	27.1	4.4	2.9	2.1	0.5	1.5
Percentage merchantable (based on total).....	2.5	1.1	3.4	0.1	0.8	0.5	0.4	.....

Forest Enemies.

FIRE.

The damage done to this reserve by fire has been enormous. Large areas have been crossed and recrossed by the most destructive fires. For miles and miles alongside the old Indian trails stretch open prairies or desolated wastes of blackened stumps. Millions and millions of feet of spruce timber have been thus destroyed within the past quarter-century by the carelessness of Indians, half-breeds, settlers and lumbermen. For although it is true that, for every acre bared by the lumberman, fire has bared twenty, yet in nearly every case that fire started in his one-acre slashing.

West of the Strathclair trail, two great fires some twenty years ago laid waste about 70 per cent of the whole area. The first one simply ran through and killed the timber, but three years later another fire followed that razed all, not leaving even a spruce seed-tree over large tracts. Then, of course, both before and since that time there has been the annual infliction of more or less destructive ground fires. These are most numerous around the outskirts of the reserve, especially bordering the Galician settlements. In order that the gravity of present conditions and the great necessity for more stringent methods of protection may be appreciated, it must be remembered that

practically all of these extensive brûlés now carry a more or less thrifty reproduction, which even a slight surface fire will kill as it runs, and that, further, local opinion, for the most part, places little or no value on this growing stock.

In the east end of the reserve, also, the work of recurrent fires is apparent over large areas, shown particularly in the denuded semi-prairie conditions all about Clear Lake. Again, north-east of the Ochre River Valley, extending from the east side of the reserve clear to Shaw's limit and covering an area of some 50 square miles, is an area burned fourteen years ago and now covered with a chaos of dry debris and ragged reproduction, fuel for another fire. In the north of Township 19, Range 16, forty-five hundred acres was burned over about eighty years ago, but for some reason nature was unable to reforest, and today it is a wilderness of alder and hazel, with here and there a scrubby birch. Then, too, as mentioned, the country bordering the main trails resembles anything but a timber reserve, and gives the yearly-increasing number of travellers a bad impression. But the era of fires in the Riding Mountains is past and gone. In spite of local scepticism, nothing is more certain than that forestry and an effective fire patrol can and will reclaim and hold these brûlés and prairies as productive permanent forests.

But although it is true, as shown above, that this reserve is at present in a most abnormal and undesirable condition, yet the fires which made it so have not impaired to any serious extent the producing power of its deep soils. It has been slight in comparison, for instance, with the awful havoc wrought by fires of similar intensity in Laurentian country. It is satisfactory to note that there is on the reserve very little waste land unsuited to tree growth except where this condition results from lack of drainage, satisfactory because it assures that every dollar spent in improving and developing the resources of the reserve will be returned with interest and that the opportunity for forestry is excellent.

METHODS OF PROTECTION.

Inasmuch as a feasible, rational and adequate solution of this fire protection problem is a simple necessity before we can hope either to hold our present area or proceed to enlarge it, the question must be candidly faced, discussed and settled. The Government has already organized the nucleus of a ranger service, which has been doing good work; still there is no doubt that the comparative immunity of the past few years has been largely due to the nature of the seasons, and no one will claim that past steps have been more than tentative. Good laws and the *Forest Warden System*, as in several of the Lake States, will do much to protect; but the larger and rougher and the more unsettled the area to be protected, the less efficient does the system become. At the best it is not flexible enough; it offers merely a remedy instead of a preventative; and yet in fire protection, if anywhere, an ounce of prevention is worth a ton of cure. Herein lies the prime virtue of the patrol system. True, it costs considerable, but so does everything worth having. The federal taxpayer, however careless about his standing timber, cannot afford to proceed with reforestation without first having the fire-risk reduced to a minimum.

DISEASE.

The spruce does not suffer seriously. A rust (peridermium) attacks the cones in wet seasons and reduces the seed yield; another fungus (*Phoma abietina*), which was bad in 1908, kills back the growing tips and gives a blighted appearance, while in the larger trees "Red Heart" from the work of *Trametes pini* sometimes occurs. Balsam, however, suffers greatly, seldom reaching a foot in diameter before being attacked, and the resulting decay is very rapid and complete. So long as it is growing vigorously, a birch tree repels all fungi, but when its vigour declines, the hoof fungus (*Polyporus betulinus*) invariably enters and destroys it. In larch and jack pine the loss from disease is practically nil. In poplars, on the other hand, the loss is most serious.

Some data was gathered last summer as to the relative soundness of aspen and balsam in order to aid in determining which species is the most useful all-round timber tree for

PLATE VII.



Typical park country in Township 19, Range 18, created by recurring fires in the past

PLATE VIII.



2965—p. 24. Spruce and Larch "Brûlé." A second fire here is almost inevitable.

PLATE IX.



"Punks" or fruiting bodies of *Polyporus* (*Fomes*) *igniarius*, the fungus which destroys the Aspen.

the Riding Mountain locality. From the strip survey returns the average percentage of apparently diseased trees was obtained, i. e. trees that the caliperman could detect by eye. Thus of 25,535 aspen trees calipered, 6,513 or 25 per cent were visibly affected, and out of 12,936 balsam trees 1,378 or about 10 per cent were diseased. A further effort was made to find what per cent of the apparently sound trees were actually diseased, both by a general study of trees taken at random and by sample plots. On the assumption that the general size for fungal affection is reached when the tree is about one foot in diameter, the range of trees studied lay between eight and fifteen inches. The following tables show the results :—

TABLE XI.—STUDY OF ASPEN PLOTS SHOWING THE PERCENTAGE OF TREES DISEASED AND HABITS OF THE FUNGUS, POLYPORUS (FOMES) IGNIARIUS.

Area. — Acres.	Total number of Aspen trees, all sizes.	Aspens visibly diseased.	Apparently sound but actually diseased.	Condition of Stand.
0.5	143	41	2	Thrifty mature stand, low ground, fair drainage.
0.5	89	47	11	Mature, unthrifty, well drained knoll.
0.5	55	22	2	Over-mature timber, 20% density; soil, rich loam.
0.5	157	61	9	Mature stand; 70% density; rolling, sandy loam.
0.5	144	57	38	Mature, tall timber; 65% density; level, excellent drainage.
0.5	85	43	11	Mature; on well drained dry ridge; sandy loam.
0.5	163	24	26	Good, mature stand; sandy loam between.
0.5	94	49	21	Over-mature; 60% density; well drained slope.
Totals.	930	344	120	.

ENTRANCE OF FUNGUS.

	POINT OF ATTACK.					
	Root.	Knots.	Broken limb.	Frost crack.	Fire scar.	Unknown.
Percentage attacked.....	33	26	23	10	1	7

Percentage affected in—Butt, 42%; Middle, 31%; Top, 16%; Throughout, 11%.

Average amount of fungus in Aspen, 50%.

TABLE XII.—DECAY IN ASPEN.
(A study of 660 apparently sound aspen trees.)

Diameter Breast-high Inches.	Total trees examined all apparently sound to the eye.	Apparently sound but actually diseased.	Per cent diseased.
8	81	30	37
9	106	28	24
10	145	37	26
11	121	32	26
12	96	28	29
13	62	20	32
14	31	7	23
15	18	3	17
	660	185	28

TABLE XIII.—DECAY IN BALM.

(A study of 177 apparently sound balm trees.)

Total trees examined all apparently sound to the eye.	Apparently sound but actually diseased.	Per cent diseased.
22	3	27
39	5	13
40	6	15
22	4	18
21	6	29
13	3	23
12	2	16
8	1	12
177	30	17

50 per cent of the Aspen is affected ; in half of these affected trees the fungus is visible, it has reached the fruiting stage ; in the other half there is no outward indication of the disease existing within. 20 per cent of the balm are diseased but only 10% are visibly diseased, and of these nearly all are also defective from wind break or frost crack.

All that can be definitely learned from the result is that in general sickly or wounded trees are attacked, and healthy trees are not. The whole matter is a health relation ; and, although this study has apparently yielded no definite results, yet it served its purpose in showing that aspen is very susceptible to the fungus, which quickly renders it useless for lumber and of small value for fuel, and that over large areas at least half the trees have been attacked by the disease and are no longer marketable.

It was found impossible to determine with any certainty the point where the fungus entered, but in aspen at least fifty per cent of the infection is through a knot or wound. The balm, unlike the aspen, are usually affected only for four to six feet at the butt, and mostly by way of the root or a frost crack.

The question as to what cultural or harvesting methods might be adopted to check these fungal ravages is a difficult one to answer. If poplar were a tolerant species like spruce, the making of improvement cuttings, which would from time to time remove the attacked trees from among their fellows, might answer. But poplar is not suited to the selection system ; it must " all grow together until the harvest ", and when the average tree reaches, say, a diameter of about twelve inches the stand should, under average conditions, be cut and natural regeneration will at once start a new stand. How much may be done to check the fungus by a careful selection of small cutting areas remains to be seen, but though some time may be required, there is no doubt that the disappearance of old, diseased and over mature stands as the result of introducing proper cultural and business methods will ultimately reduce the loss to a merely nominal one. Upon the whole, aspen and balm are about of equal value at present for propagation on the reserve, but both should be discarded just as fast as such conifers as red pine and white spruce can be made to replace them.

INSECTS.

While insects are doing some damage, notably the spruce bark borers (*Dendroctonus*) and aspen defoliators (*Lina scripta* and *Lina lapponica*), yet on the whole they merit no special attention, for the predaceous varieties, such as the ground beetles, are keeping the others well in check. A matter for congratulation, too, is the fact that the destructive larch sawfly (*Nematus erichsonii*), which has ruined whole forests in Eastern Canada, has not as yet reached the reserve.

WIND.

Wind will always be an important factor in spruce-cutting operations, owing to the shallow-rooted nature of this species. Even in wild woods the loss from this agency is considerable. High winds are a normal condition in the Riding Mountains, and the average velocity is probably twice that in Maine, where the wind factor was found so important as to control absolutely the diameter-cutting limit. Aspen is never uprooted, but when weakened by disease is easily snapped off at eight to ten feet up, and in old timber these wind falls are very numerous. The balm suffers in a different way, fully one third being subject to ring shake at the butt. Again, these violent winds favour the spread of forest fires and render the successful fighting of them, when once under way, an almost impossible task.

FROST.

Frost reduces the general quality of the butt logs in balm to a marked degree. Fully fifty per cent of these show frost-cracks extending up four to six feet. Many aspen, too, exhibit this defect, which is one more reason for replacing these poplars with spruce.

TABLE XIV.—FROST CRACK IN BALM.

(A study of sample plots to show the prevalence of frost crack in balm.)

Area, Acres.	Township.	Total number of balm trees.	Number frost cracked.	Percent.	Represents trees	Condition of stand.
				%		
0.5	20-22	137	75	55	4 inch. and over.	Over mature, crooked limby trees. Land, clay-loam, rolling and well drained.
0.5	20-22	83	48	57	"	Timber, 80 years old, mature, fairly thrifty. Rolling well drained loam.
0.5	20-22	89	45	51	"	Mature stand, nearly level along creek.
0.5	22-18	50	14	28	4 inch. and over.	Thrifty, semi-matured stand in moist bottom land.
0.5	21-19	78	46	58	8 inch. and over.	Open limby timber, on level rich loam.
0.5	21-19	84	46	55	"	55 ft. 75-year-old stand, rather open and limby; 50 per cent density; good rich soil.
Total.	.....	571	288	.....	.....

Average per cent of frost crack in balm: 52%.

MAN.

Indirectly, man himself, through carelessness, destructive lumbering and indiscriminate cutting, where these have resulted in fire and windfall, has been responsible for great destruction.

Study of Species.

There are eight more or less important native species on this reserve; namely, white and black spruce, aspen (white poplar), balm (black poplar), larch, canoe birch, balsam

and jack pine. The larch, birch, balsam and black spruce are important only from the quantity of these now on the reserve, and not from their intrinsic value as timber trees. The same is true in a lesser degree of the pine and poplars. White spruce is the species to be favoured over all others in future management. Of course, nature puts limits to this replacement, for on the muskegs and drier sands only slow-growing inferior species can live.

WHITE SPRUCE (*Picea canadensis*).

In the absence of any more valuable member of the coniferous family (as, for instance, the white or red pine) the white spruce naturally becomes the most important timber tree on the Riding Mountain Reserve, the tree of greatest all-round utility.

Owing to the uniform topography it grows in all parts of the reserve where drainage is sufficient, thriving best, however, on well drained moist loams and clays. It is not fastidious regarding aspect or situation if the soil-moisture is suitable. At present it is usually found in mixture with the poplars, birch, balsam and even tamarack, but in spots occurs pure as the remnants of old stands where time has allowed it to crowd out all competitors.

A mature tree in a crowded stand forms a long clear full trunk with a rather short compact crown or top, but in open growth or on poor soil the trunk is short and the crown long. The root system is entirely superficial, forming a wide-spread shallow mat. Hence the tree is very easily wind-thrown. Spruce is a remarkably tolerant tree all through life; but most markedly so in youth. It can exist under dense shade for a century, and then on getting full light grow precisely as fast as though it had never been stunted. "Once a runt, always a runt" has no significance here.

Although white spruce is a prolific seeder and the seedlings can arise and maintain themselves in dense shade, yet on the whole the natural regeneration of the species on this reserve is very poor among the aspen, even where plenty of seed trees are present. This is no doubt due to the moisture deficiency. If it were from an excess of humus, how explain the close stand of black spruce on the muskeg borders, or the white spruce seedlings covering unburnt slashings in the dense spruce stands of certain parts? It must be remembered that the moisture conditions in Manitoba are very different from those of Quebec, the precipitation being only about one-third as great. Moreover, the average velocity of the dry prairie winds which constantly sweep this reserve is twice that obtaining in Quebec. The evaporation loss, therefore, is very great, leaving a correspondingly small amount to meet the demands of tree growth.

Once well established, a pure white spruce stand would be permanent, as the abundant young growth in parts of the spruce type proves, provided always that the balsam could be prevented from coming in, as so frequently results after spruce lumbering operations in northern forests.

White spruce flourishes on this reserve, the rate of growth, considering the short season, being quite rapid. The tables given show the height and diameter growth of the average tree from the seedling stage upward, and the volume growth of a thrifty tree on well drained loam. It is true that these tables attempt to show the average for a greater range of conditions than is desirable, but even so they are of much value in suggesting the general quality and possibilities of this reserve for the production of spruce.

PLATE X.



Typical Open-Grown White Spruce. Of little value for lumber.

PLATE XI.



Larch and White Spruce Cones. The product of a good seed year. About 60 per cent of the spruce cones are attacked by a fungus (peridermium).

TABLE XV.—WHITE SPRUCE. TABLE BASED ON AGE OF TREES SHOWING GROWTH IN DIAMETER AND HEIGHT.

(Average tree for all sites).

Age.	D. Bh.	Periodic Diameter Growth.	Height.	Periodic Height Growth.
Years.	Inches.	Inches.	Feet.	Feet.
10.....			2.0	2.0
20.....	1.0		8.5	6.5
30.....	2.4	1.4	16.5	8.0
40.....	4.2	1.8	25.5	9.0
50.....	6.1	1.9	35.5	10.0
60.....	8.0	1.9	45.0	9.5
70.....	9.6	1.6	52.5	7.5
80.....	11.0	1.4	59.0	6.5
90.....	12.2	1.2	64.0	5.0
100.....	13.1	.9	68.0	4.0
110.....	14.0	.9	71.0	3.0
120.....	14.8	.8	73.5	2.5
130.....	15.6	.8	75.5	2.0
140.....	16.3	.7	77.0	1.5
150.....	16.8	.5	78.0	1.0

The above table shows the rate in growth of the average white spruce tree. The first column gives the age in decades, the second column the diameter breast-high at the end of each decade. In the third column is given the total diameter growth for the previous decade. Similarly the fourth column shows the average height at the end of each decade and the last column gives the total growth in height for the previous decade. Thus a tree 70 years old is 9.6 inches in diameter; between its sixtieth and its seventieth year it increased in diameter 1.6 inches; it is 52.5 feet high and between its sixtieth and seventieth years it increased in height 7.5 feet.

TABLE XVI.—WHITE SPRUCE. VOLUME TABLE.

(Compiled from the measurements of 46 trees.)

Age.	D.Bh. out-side bark.	D.Bh. in-side bark.	Total Height.	MERCHANTABLE LENGTH.		Total Volume (in-side bark).	MERCHANTABLE VOLUME.	
				Fuel to 4 in. at top.	Logs to 6 in. at top.		4 in. and over—fuel.	6 in. and over—logs.
Years.	Inches.	Inches.	Feet.	Feet.	Feet.	Cu. Ft.	Cu. Ft.	Bd. Ft Scribner rule.
10.....			3.5			0.013		
20.....	6.80	0.7	8.5			0.044		
30.....	2.50	2.3	18.0			0.315		
40.....	4.45	4.1	28.0	4.0		1.252		
50.....	6.30	5.8	41.0	15.0	2.5	3.258	2.384	
60.....	8.25	7.6	57.0	26.0	14.0	6.653	4.875	10
70.....	10.10	9.4	64.5	36.0	24.0	11.984	10.865	25
80.....	12.05	11.3	72.0	43.0	31.5	17.996	16.500	50
90.....	13.70	12.9	75.0	49.5	38.5	25.340	23.575	80
100.....	15.45	14.6	77.5	54.5	44.0	32.340	30.745	160
110.....	17.05	16.2	79.0	58.5	48.5	40.749	38.675	250
120.....	18.65	17.7	80.0	62.0	52.5	50.034	47.375	310
130.....	20.20	19.2	83.5	65.0	56.0	59.126	56.800	360
140.....	21.70	20.6	86.0	67.5	59.0	69.099	66.190	430
150.....	23.10	21.9	88.0	70.0	61.0	78.783	75.385	520

The above table gives the growth, rate and merchantable contents of the best white spruce timber. The first four columns give the age, diameter breast-high and height as explained under Table XV; the fifth column gives the merchantable length if the tree be taken for fuel to 4 inches at the top; the sixth column gives the number of feet of logs that can be cut out if the tree is taken to 6 inches at the top; the seventh column gives the total contents of the tree in cubic feet; the eighth column gives the cubic feet of cordwood that the tree will make if cut to 4 inches in the top, and the last column gives the number of board feet that the tree will cut, Scribner scale, if taken to 6 inches in the top.

TABLE XVII.—TABLE SHOWING HEIGHT AND DIAMETER GROWTH IN WHITE SPRUCE REPRODUCTION.

(Based on measurements of 274 seedlings in good soil for spruce.)

Age.	Height.	Diameter at ground (outside bark).
Years.	Feet.	Inches.
1.....	0.10	0.02
2.....	0.15	0.04
3.....	0.27	0.07
4.....	0.40	0.10
5.....	0.54	0.13
6.....	0.72	0.16
7.....	0.90	0.20
8.....	1.12	0.24
9.....	1.37	0.28
10.....	1.70	0.33
11.....	2.20	0.42
12.....	2.75	0.53
13.....	3.60	0.70
14.....	4.65	0.91
15.....	6.00	1.18

BLACK SPRUCE (*Picea mariana*).

This species is practically confined to the poorly drained areas, and may occur in close pure thickets or in mixture with larch. In typical situations it is a short spindly tree, of very slow growth, and useless for any purposes other than fuel and fencing. From early life it is a prolific seed-bearer and the natural reproduction is excellent.

TABLE XVIII.—BLACK SPRUCE. VOLUME TABLE.

(Based on measurements of 34 trees.)

Diameter Breast-high (outside bark.)	Total Volume.	Diameter Breast-high (outside bark.)	Total Volume.
Inches.	Cubic ft.	Inches.	Cubic ft.
1	0.1	6	2.7
2	0.2	7	4.1
3	0.5	8	6.0
4	1.0	9	8.0
5	1.6	10	11.9

TABLE XIX.—BLACK SPRUCE. TABLE SHOWING GROWTH IN DIAMETER AND HEIGHT.

(Based on measurements of 34 trees.)

Age.	Diameter Breast-high (outside bark).	Height.
Years.	Inches.	Feet.
10.....	.....	1.7
20.....	0.3	5.6
30.....	1.1	10.5
40.....	2.0	15.5
50.....	2.8	20.6
60.....	3.8	26.0
70.....	4.8	30.8
80.....	5.6	35.0
90.....	6.4	39.0
100.....	7.1	42.0
110.....	7.6	45.0
120.....	8.1	48.0
130.....	8.6	50.0
140.....	9.0	51.0

ASPEN. (*Populus tremuloides*.)

While it may be well to give a frank recognition at once to the fact that this species is of slight value as a producer of saw material, yet it has played a very important part in supplying the wood wants of the western settler, and is to-day, by virtue of its ubiquitous occurrence and great fuel value, a tree of immense utility, especially in view of the general absence of other and better species.

Aspen occurs in nearly pure stands, or more often mixed with such associating species as balsam, birch and spruce. It prefers a fresh loam, but only the extremes of drouth and moisture can forbid its growth entirely. It is a tree that demands light all through life, so that there is no range of age classes as in spruce; all the trees must start together forming what is called an "even-aged" stand. The downy wind-borne seed is produced in June every year in great abundance, which explains why all fire-swept areas are so rapidly re-clothed with poplar. In close stand the aspen has a straight smooth bole and small open crown. The size of mature trees varies with the moisture supply, from the crooked sickly specimens of 40 feet in height and 8 inches in diameter, common on the light sandy soils of the upper plateau, to the straight vigorous well-cleaned trees on choice sites, reaching sometimes 80 feet in height and 2 feet in diameter, breast-high while still sound.

The wood is light, soft, not strong and difficult to season properly. It makes excellent box and slack-cooperage material, however, and durable flooring of snowy whiteness. It is, of course, excellent firewood, a use which is likely to be more important than all others combined.

Almost no figures have been published to date on this continent as to the height, diameter, or volume growth of this species. One reason is the relatively unimportant place of the species; another is the great indistinctness of the annual rings, which makes the work slow and often unsatisfactory. Some measurements were taken each year by the field parties in the Riding Mountains and other neighbouring reserves, and the tables given below are compiled from this source.

Table XXI shows that the average annual height growth during the first 25 years is 1.2 feet, and the breast-high-diameter growth, 0.14 inches; or if the first 20 years are taken the respective figures are approximatively one foot and one tenth of an inch.

In Table XXII the volume of the average trees in board feet is given by the Scribner Log Rule. It will be seen that even if the tree were free from defect its yield of

sawn lumber would be relatively small. But as a matter of fact fully eighty per cent of the mature aspen on this reserve is unfit for sawing. Hence but slight value can be placed on this tree as a producer of merchantable timber. It is in every way an inferior and undesirable species from the standpoint of the lumberman.

TABLE XX.—ASPEN. TABLE SHOWING PERCENTAGE OF BARK AT DIFFERENT AGES.

Diameter, Breast-high (outside bark).	Percentage of Bark.	Diameter, Breast-high (outside bark.)	Percentage of Bark.
Inches.		Inches.	
2	26	10	15
4	21	12	15
6	17	14	15
8	16	16	15

This table is from a curve drawn for 59 trees and shows that while the 2 inch tree is fully one-fourth bark, the proportion rapidly decreases, until in a 10-inch tree it has fallen to 15 per cent, which remains a constant or very nearly so.

TABLE XXI.—TABLE SHOWING HEIGHT AND DIAMETER GROWTH IN ASPEN REPRODUCTION.

(Compiled from measurements of 272 trees.)

Age.	Height.	Diameter at ground (outside bark).	Diameter Breast-high (outside bark).	Age.	Height.	Diameter at ground (outside bark).	Diameter Breast-high (outside bark).
Years.	Feet.	Inches.	Inches.	Years.	Feet.	Inches.	Inches.
2	1.7	0.25	.....	14	15.0	2.10	1.35
4	3.6	0.55	.....	16	17.2	2.45	1.60
6	5.8	0.90	0.40	18	19.8	2.75	1.95
8	8.2	1.25	0.75	20	22.4	3.10	2.35
10	10.3	1.55	0.95	22	26.0	3.50	2.80
12	12.7	1.80	1.15	24	28.8	4.00	3.30

TABLE XXII.—ASPEN. VOLUME TABLE.

(Based on measurements of 62 trees.)

Age.	Diameter Breast-high (outside bark.)	Diameter Breast-high (outside bark.)	Total Height.	MERCHANTABLE LENGTH.		Total Volume.	MERCHANTABLE VOLUME.	
				Fuel to 4 in. at top.	Logs to 6 in. at top.		For fuel to 4 in. at top.	Logs to 6 in. at top.
Years.	Inches.	Inches.	Feet.	Feet.	Feet.	Cu. ft.	Cu. ft.	Bd. ft. Scribner.
10	0.8	1.05	11	.....	.....	0.007	.....	.....
20	2.0	2.4	22	.....	.....	0.231	.....	.....
30	3.4	3.9	32	.....	.....	1.040	.....	.....
40	4.8	5.4	41	11	.....	2.342	1.170	.....
50	6.2	7.2	49	23	5	4.640	3.567	5
60	7.3	8.6	55	31	13	7.685	6.440	10
70	8.3	9.9	60	38	21	10.356	9.222	25
80	9.1	10.9	63	44	27	12.515	11.349	35
90	9.8	11.7	65.5	47	31.5	15.069	13.852	50
100	10.2	12.3	67	49.5	36	16.538	15.335	65



[Photo by *H. R. MacMillan*.]

70-year old stand of Balm on site of first quality. Averages 10 inches in diameter breast-high and 65 feet in height.

TABLE XXIII.—ASPEN. TABLE SHOWING PROBABLE FUTURE YIELD.

Table constructed from actual measurements of rate of growth in dense stands of poplar now covering very large areas of the Forest Reserves in Manitoba, giving a reliable, conservative estimate of future yield.

Age.	No. Trees. per acre.	Average Diameter Breast-high.	Average Height.	Average Volume per Tree.	Yield per Acre.
Years.		Inches.	Feet.	Cu. ft.	Cords.
10	4,000	1·5	13·5	0·1	4
20	2,500	3·2	28·0	0·8	22
30	1,200	4·7	38·0	2·4	32
40	850	6·0	46·5	4·3	41
50	625	7·2	51·0	6·8	47
60	425	8·7	54·0	11·1	52
70	335	10·1	56·5	14·0	55
80	300	11·1	58·0	17·4	58

It will be seen that a forty year rotation would be a very satisfactory one in poplar, for fuel production.

BALM OF GILEAD (*Populus balsamifera*).

This tree is locally known as the "black poplar" and in many ways bears a general resemblance to the aspen. They spring up together on all denuded areas, the moisture contents of the soil afterwards determining the relative amount of each species in the resulting stand of timber. The balm demands more moisture, and on many creek bottoms and poorly drained swampy tracts it flourishes to the total exclusion of the other. On dry sites, however, it mixes more and more sparingly with the aspen until the latter stands alone. Bordering all muskeg areas, it is found in more or less intimate mixture with the spruces, balsam and larch.

This species, while much less diseased than the aspen, suffers more from other defects. On the whole it will saw out 20 per cent more of sound material. The wood, though perhaps slightly stronger and tougher than aspen, is unsuitable for flooring and its fuel value is very low.

The growth rate of balm does not differ markedly from that of aspen, as the following figures show :

TABLE XXIV.—BALM. TABLE SHOWING GROWTH IN HEIGHT AND DIAMETER.

(Computed from measurements of 33 trees),

Age.	Height.	Diameter Breast-high.	Age.	Height.	Diameter Breast-high.
Years.	Feet.	Inches.	Years.	Feet.	Inches.
10	10·0	1·0	60	56·2	8·0
20	22·5	2·6	70	60·5	8·8
30	34·0	4·2	80	63·8	9·5
40	42·6	5·6	90	65·0	10·1
50	50·3	7·0	100	65·0	10·6

JACK PINE (*Pinus Banksiana*).

This is the only pine on the reserve. Trees which have grown in close stand reach 60 to 80 feet in height and 12 to 18 inches in diameter, with straight, fairly clear trunks, and yield a good grade of saw-timber and tie material; but where open grown they are a mass of limbs right to the ground and of little value even for fire wood. In other words, the timber value of a jack pine varies directly with the density of the forest in which it grows. Owing to the very persistent branches, jack pine lumber is very knotty, as a rule, and of low commercial value or utility. This tree should be confined strictly to such parts of the reserve as will not produce better species.

Jack pine flourishes on the dry sandy plains east of Clear Lake. Its nature is to form an extensive pure stand after a fire, and only where spruce seed trees were also present, or later fires created openings for birch and poplar, is it found mixed with other species. The root system is deep enough to prevent windfall, and the defect in standing timber due to insects and disease is not over two or three per cent. Many of the trees are, however, more or less disfigured by a "witches' broom" fungus (probably *exoascus deformans*.)

The natural reproduction of jack pine on this reserve is good. The seedlings demand full light on a mineral soil, just the condition found after a fire. Each tree, moreover, is a storehouse of seed, and, as the fire not only prepares the seed-bed but also unlocks this supply, a dense young stand results.

There is an area of 15 square miles in Townships 19 and 20, Range 17, now bearing such a young growth, part of which is eight, the rest fourteen years old. Should a second fire now sweep through this resinous mass of saplings and debris, even the seed-trees will vanish and the whole tract become prairie.

Jack pine differs markedly from spruce or white pine in its habits of growth. The latter grow in a slow persistent uniform way for two or three centuries, but the former resembles larch in growing rapidly during early life and practically quitting at 60 or 70 years. The following tables are compiled from data gathered on the Riding Mountain and "The Pines" Reserves:—

TABLE XXV.—JACK PINE. TABLE SHOWING TOTAL HEIGHT AND CLEAR LENGTH ON DIAMETER BASIS.

(Based on measurements of 224 trees in a typical jack pine stand).

Diameter Breast-high.	Total Height	Clear Length*	Diameter Breast-high.	Total Height	Clear Length*
Inches.	Feet.	Feet.	Inches.	Feet.	Feet.
1.....	10	.....	8.....	54	26·5
2.....	21	.....	10.....	59·5	27·0
3.....	30	.....	12.....	61·0	27·5
4.....	38	20	14.....	63·0	28·0
5.....	44	22·5	16.....	64·3	28·0
6.....	48	24·0	18.....	65·0	28·0

*The clear length is the height from the ground to the first green branches.

TABLE XXVI.—JACK PINE. TABLE SHOWING GROWTH IN DIAMETER,
ON THE BASIS OF AGE.

(Compiled from measurements of 50 representative trees).

Age.	Diameter, Breast-high, (outside bark.)	Age.	Diameter, Breast-high, (outside bark.)
Years.	Inches.	Years.	Inches.
10	0·5	60	10·1
20	2·8	70	11·0
30	5·4	80	11·7
40	7·3	90	12·2
50	8·8	100	12·6

The volume tables below, as constructed by Mr. H. R. MacMillan for "The Pines" Reserve, are also applicable to the jack pine of the Riding Mountains, because the growth-rate and taper are practically the same for both localities. The cubic contents by 8-foot logs is a convenient standard, whether for posts, ties, timber or fuel.

TABLE XXVII.—JACK PINE. VOLUME TABLE SHOWING CONTENTS
OF EACH LOG IN CUBIC FEET.

(Logs taken to 4 inches at the top).

Diameter breast-high, (outside bark.)	1st Log.	2nd Log.	3rd Log.	4th Log.	5th Log.	6th Log.	7th Log.	Total.
Inches.								cu. feet.
4.....	0·730							0·730
5.....	1·140	0·600						1·740
6.....	1·650	0·960						2·610
7.....	2·170	1·430	0·876					4·476
8.....	2·790	1·940	1·164	0·760				6·654
9.....	3·484	2·564	1·396	1·268				8·712
10.....	4·272	3·124	2·496	1·884	1·100			12·876
11.....	5·052	3·700	3·048	2·400	1·544			15·744
12.....	5·924	4·416	4·024	2·872	2·020	1·076		20·332
13.....	6·832	5·008	4·120	3·352	2·512	1·468		23·292
14.....	7·856	5·640	4·640	3·792	2·848	1·832	1·020	27·628

TABLE XXVIII.—JACK PINE. VOLUME TABLE SHOWING CONTENTS IN BOARD
FEET (SCRIBNER RULE) OF LOGS 8 FEET LONG. LOGS TAKEN TO
6 INCHES AT THE TOP.

Diameter Breast-high (outside bark.)	CONTENTS IN BOARD FEET. (Scribner "Decimal C" Rule).						
	Butt log.	Log 2.	Log 3.	Log 4.	Log 5.	Log 6.	Total.
Inches.							
6.....							
7.....	5						5
8.....	5	5					10
9.....	10	5	5				20
10.....	10	10	5	5			30
11.....	20	10	10	5			45
12.....	20	20	10	10			60
13.....	30	20	10	10	5		75
14.....	30	20	20	10	5		85

TABLE XXIX.—JACK PINE. TABLE SHOWING TAPER OF LOGS.

Diameter Breast-high (outside bark.)	Diameter inside bark at given heights above ground.					
Inches.	9 ft.	17 ft.	24 ft.	32 ft.	40 ft.	48 ft.
6.....	5.3	.....	.....	.....	.....	.....
7.....	6.2	5.2	.....	.....	.....	.....
8.....	7.1	6.2	4.8	.....	.....	.....
9.....	8.1	7.2	6.0	4.7	.....	.....
10.....	8.9	8.1	7.1	6.0	3.8	.....
11.....	9.6	8.8	7.9	6.8	4.9	.....
12.....	10.5	9.5	8.6	7.6	5.8	.....
13.....	11.2	10.2	9.3	8.3	6.8	4.6
14.....	12.0	10.7	9.8	8.8	7.4	5.5

The above table is the basis for Table XXVIII.

LARCH OR TAMARACK (*Larix laricina*).

Owing to the strength of this timber and its durability in contact with the ground, combined with great clear length and small taper, it is a very valuable species for posts rafters, fencing and construction work generally. Moreover, it is the favourite and highest priced fuel wood on the local markets. But although it is for these reasons a tree of vast utility to the settler, yet to the mill man it is a "light-bodied" tree, normally of too small diameter to cut into profitable saw material. For this reason larch should not be favoured over white spruce on good soils, but for all the more poorly drained areas it is the species to be favoured.

It occurs in small pure stands of limited area or more often, especially where the drainage is better, mixed with black spruce. If the water table is too near the surface it is of very slow growth and remains always spindly and stunted, a tree of three to five inches in diameter and twenty to thirty feet high; but along swamp borders and on hill sides where seepage occurs it flourishes, some specimens reaching 15 inches d.b.h. and 70 feet in height.

Larch does not prefer the cold sphagnum bogs and muskegs, but is almost confined to such sites by the keen competition of other species. A tree grown in good soil has a tall slender shaft and small narrow crown; in the open, vice versa. In deep muddy swamps the roots are long and stringy, on drier land they are sturdier; in all situations the tree is wind-firm. Being very intolerant, larch is always found either in pure even-aged stands or as a dominant tree in mixture.

Larch reproduces only by seed borne in small purple cones which mature in one season. It is a prolific but irregular seeder. Natural regeneration is quite satisfactory in suitable openings, so that in lumbering a thrifty new stand may be assured by leaving sufficient seed-trees.

Although some damage is done by bark beetles the tree has no serious enemy, the saw-fly not having appeared as yet.

The life history is quite similar to jack pine. In both the early height-growth is extremely rapid, the diameter accretion being postponed until the stand thins out and the more vigorous trees can secure an abundance of sunlight.

Both larch and jack pine are short-lived, and for larch, at any rate, the most profitable commercial rotation will not exceed 60 years. The table below is from measurements taken in the Riding Mountains. The growth in muskeg is seen to be much slower but even more persistent than on the higher land.



White Birch Coppice. A dozen strong sprouts from the old root.

TABLE XXX.—LARCH. TABLE SHOWING HOW HEIGHT AND DIAMETER GROWTH OF LARCH IS AFFECTED BY DRAINAGE CONDITIONS.

Age.	UPLAND SITE (130 TREES).		MUSKEG SITE (89 TREES).	
	Diameter Breast-high (outside bark)	Total Height.	Diameter Breast-high (outside bark)	Total Height.
Years.	Inches.	Feet.	Inches.	Feet.
10.....	0·6	5·5	.....	1·4
20.....	1·9	16·0	.....	4·5
30.....	4·0	28·0	1·0	10·0
40.....	6·0	40·0	2·1	15·5
50.....	7·5	49·0	3·4	20·5
60.....	8·4	57·0	4·4	26·0
70.....	8·8	61·0	5·1	30·5
80.....	9·1	62·0	5·6	35·0
90.....	9·2	62·5	6·1	38·5
100.....	9·25	63·0	6·5	41·0
120.....	.....	.....	7·3	45·5
140.....	.....	.....	8·0	50·0

BALSAM (*Abies balsamea*.)

This species is of comparatively slight importance. The tree is small and short-lived, because it suffers so from disease, and the wood is weak and not durable. Both from the standpoint of settler and lumberman it is of low utility and should be discouraged. This will be difficult, however. In fact, to prevent balsam from seeding cut-over spruce lands, as is now occurring on parts of this reserve, will form one of the forester's chief problems. Where possible all balsam seed-trees should be cut or gridled in lumbering.

Balsam occurs mixed with the spruces in moist situations. It is tolerant, fairly wind-firm and a prolific seeder. The growth rate is very slow, it resembles spruce in nature of growth but is less persistent, as shown by the following table :—

TABLE XXXI. BALSAM. GROWTH IN HEIGHT AND DIAMETER, BASED ON AGE.
(Computed from measurements of 28 trees.)

Age.	Height.	Diameter, Breast-high (outside bark.)	Age.	Height.	Diameter, Breast-high (outside bark.)
Years.	Feet.	Inches.	Years.	Feet.	Inches.
10	3	.....	50	29	4·8
20	6	0·4	60	39	6·6
30	11	1·4	70	46	8·3
40	18	2·8	80	51	9·4

PAPER BIRCH (*Betula alba* var. *papyrifera*.)

This species prefers a light loam soil and occurs either in almost pure stand or mixed in varying proportion with white spruce and aspen. It is estimated there is about 15,000,000 board feet of birch fit for saw material on the reserve, but the greater part is too small and crooked for such use. On the limits the best trees are being cut to furnish flooring, which sells at \$30 to \$35 per M. Birch makes good firewood, and

no doubt most of the present supply will be thus used. On the whole it is an inferior species, and, except for the small supply needed for special uses to which it is adapted, will not be a factor in future management.

TABLE XXXII.—PAPER BIRCH. GROWTH IN HEIGHT AND DIAMETER, BASED ON AGE.
(Computed from measurements of 24 trees.)

Age.	D. Bh. (outside bark)	Height.	Age.	D. Bh. Outside Bark.	Height.
Years.	Inches.	Feet.	Years.	Inches.	Feet.
10	1	9	60.....	8.4	49
20.....	1.8	20	70.....	9.6	54.5
30.....	3.2	29	80.....	10.6	58
40.....	5.2	37	90.....	11.5	61
50.....	6.8	44	100.....	12.2	62.5

Paper birch is intolerant, but less so than poplar. The deep spreading root-system makes it entirely wind-firm. Reproduction is secured both by seed and sprouts, the coppice growth being luxuriant after a fire or cutting. The growth rate is slow, and this fact, along with the weight of the timber, its serious percentage of defect from crook and its limited utility and market, makes this species unworthy of consideration as a commercial competitor with the conifers. We have no measurements as yet sufficient for construction of a volume table. The following table is from figures gathered in the New England States by the United States Forest Service. Riding Mountain birch is of poorer quality and will run five per cent less all round.

TABLE XXXIII.—PAPER BIRCH. TABLE SHOWING VOLUME IN CORDS PER TREE.

Diameter Breast-high (outside bark).	MERCHANTABLE LENGTH—FEET.			
	10.	20.	30.	40.
Inches.				
5	0.02	0.03		
6	0.02	0.04	0.05	
7	0.03	0.05	0.07	0.08
8	0.04	0.07	0.09	0.11
9	0.05	0.08	0.11	0.13
10	0.07	0.12	0.13	0.16
11	0.07	0.12	0.16	0.19
12	0.08	0.14	0.19	0.22

In the above table the trees are divided into height classes, and for each height class a volume is given. Thus an eight-inch tree of a merchantable or usable length, approximately 10 feet, contains .04 cords of fuel, but if the usable length is 20 feet it contains .07 of a cord of fuel, and so on.

Utilization of Species.

LUMBER.

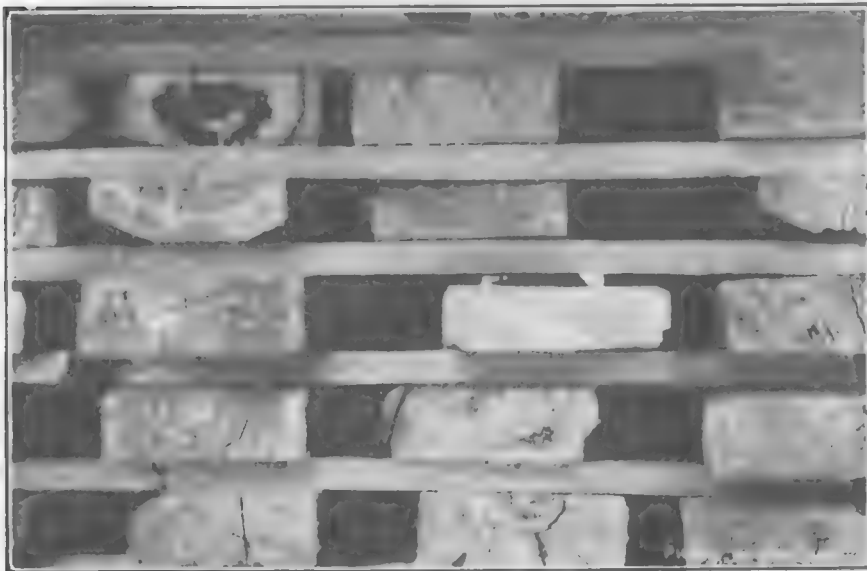
(1). SPRUCE.

Commercial lumbering operations are practically confined as yet to this species. The large mills may saw a good poplar log now and again or a little larch, but they



[Photo by J. R. Dickson.]

Sawmill of Mr. J. Sennett, Shortdale. The spruce logs in the foreground run about fifteen to the thousand feet. This mill, with planer, employs 25 men and manufactures 15,000 feet per day.



Balm Lumber in pile, showing prevalence of Wind-Shake and other defects.

figure only on the spruce log run. Approximately eighty million feet of spruce logs were cut during the winter of 1908-9 on the timber limits of the Dauphin district. About one-fifth of this, 16,000,000 feet, was cut from the Riding Mountain Reserve. The wholesale price for spruce runs from \$12 to \$17 per M. and the retail from \$16 to \$28, depending on the quality. There is a tendency toward rising prices. In general the accessibility of the timber, low grades and the long season allowed for the making and maintenance of iced roads makes logging easy in this region. Driving is done on the larger streams. One-horse skidding is the rule, except for heaviest logs. The general length of logs is 12 to 16 feet, and most operators are now cutting to about 8 inches at breast-height and 6 inches in the top. The cost of producing the lumber from the stump until loaded on the car is set forth in the following sworn figures by one of the largest companies :—

ITEM.	COST PER M. FOR	
	(5-12 mile haul.)	(3-8 mile haul.)
	\$	\$
Logging.....	8.00	6.00
Sawing.....	2.75	2.75
Government dues.....	0.75	0.75
Planing, hauling and loading on car.....	1.80	3.00
Total.....	13.30	12.50
Average cost price at car.....		12.90 per M.
Average selling price at car.....		15.68 "
Average profit.....		2.78 "

There is no uniformity in scaling. The Doyle Rule is perhaps most generally used ; some, however, employ the Scribner, and others, who do their own logging and hence have no occasion to scale in the log, employ none. As the average cut of spruce in this region will run 15 logs per M. the Scribner decimal C rule, gives much fairer results than the Doyle rule. It is prescribed for Government use and might well be generally adopted by the lumbermen.

Most of the spruce is sawn to inch lumber or plank and dressed, but considerable dimension material is shipped in the rough for elevator construction and other building work. The prairie settlements offer an excellent and constantly growing market. The certainty of this continuous and increasing demand is the strongest argument for a vigorous forestry policy on the Riding Mountain Reserve.

The best spruce still remaining on this Riding Mountain Reserve is on the limits ; outside of these tracts it is for the most part too small and limby to yield other than a local supply of low-grade lumber.

(2) POPLAR.

Owing to the plentiful supply of spruce few uses have been found for poplar lumber. It is almost unknown on the market. Good aspen, however, makes an ideal flooring and is well suited for inside carpentry. When seasoned it is lighter as well as stronger than spruce, and often shows a pretty grain. Aspen lumber makes good box-board and slack cooperage material.

Either aspen or balsam is difficult to season properly. It does not shrink much, but checks and warps badly. But by special methods of piling and curing, such as used with the red gum and cottonwood of the Southern States, it could be handled with

success. Owing to its greater weight, slippery bark and high percentage of defect poplar logging is twenty per cent more costly than spruce. With regard to a market for this species, a matter of some importance on the Riding Mountain Reserve, the following opinions of several of the most prominent local lumbermen are of interest: 'There is absolutely no market for poplar lumber in commercial quantity. More money would be lost in attempting to utilize it than by letting it rot on the ground.' Another writes: 'Poplar lumbering is certain to be a losing proposition under present conditions.' A third gives his opinion as follows:—'At present spruce is so cheap that any one can buy it, and while that condition lasts the securing of a market for poplar is out of the question.'

There is no definite data as yet as to whether either poplar has a distinct advantage over the other in all-round utility. Opinions differ. Upon the whole, as the result of experience and inquiries made of millmen and settlers, it would appear that one is as valuable as the other. The respective good and bad points of each may be summed up as follows:—

<i>Aspen.</i>	<i>Balm.</i>
Excellent firewood	Very poor firewood.
Badly affected by <i>Polyporus igniarius</i> (hoof fungus).	Not affected by <i>P. igniarius</i>
Lumber light, strong and easily worked, but checks and warps badly.	Lumber light, strong and easily worked, but checks and warps badly.
Fine, white durable flooring.	Useless for flooring.
Good cooperage and box material.	Good cooperage and box material.
Not subject to frost cracks.	Very subject to frost crack.
Not subject to wind-shake.	Frequent wind-shake at butt.

(3) OTHER SPECIES.

Some birch is being sawn for flooring, and the best balsam is cut and mixed with the spruce. The best larch and jack pine also is being culled to fill farmers' permits or is cut on the limits for the production of railway ties.

CORDWOOD.

Cordwood prices vary with the species. Larch is the favourite fuel-wood, birch next, followed by aspen and spruce, between which there is little choice; oak is not a factor on the market and balm no one wants. Dauphin retail prices per long cord in the fall of 1908 ran about as follows: Larch \$5.00; Birch \$4.50; Aspen and Spruce \$4.00; the farmer's delivery price was about a dollar less in each case. Several thousand cords of wood leave the reserve each year, and were it not for the 50-mile limit clause in the regulations, very much more would be cut and shipped into Southern Manitoba and Saskatchewan. If an amendment of this clause to suit the needs of these settlers, cut off as they are from any other accessible supply, can be introduced in such a way as to relieve the present tension, while safeguarding local interests and the permanent welfare of the reserve, it should be done.

OTHER USES.

Lath is manufactured as a log product and sells at 15 cents per bunch of 50. Few, if any, ties are cut in the Riding Mountains, but the settlers take out each winter a large aggregate quantity of building logs, roof poles and fencing material. They should be encouraged in every way to use poplar and birch for these purposes and thus conserve the conifers.

Game on the Reserve.

The Riding Mountain Forest Reserve is the home of a diversified and valuable fauna, including both large and small game. Of first importance is the fine herd of wapiti, though there are also various kinds of deer, black and cinnamon bear and some moose—the last named chiefly in the better-wooded parts of the east end. The beaver are slowly increasing. However, the country around the reserve is being more and more closely settled, with a consequent network of trails through the mountains. This accessibility to local attack, combined with the rapid increase of outside licenses, will soon deplete the big game unless offset by the creation of a close preserve of several townships where no shooting or trapping will be tolerated. All the local people interviewed on the subject agree that this proposed step in the interests of game, is an excellent, feasible and necessary one. Moreover, it will be profitable as assuring the permanence of a large hunting-license revenue. Nor would the purposes of a game preserve interfere with the uses of forestry. Finally, the area recommended is well adapted to the project, easily protected and gives a variety of conditions suitable for every species of game.

Value of the Reserve as a Water Reservoir

Beyond question, the forest cover on these hills exercises an important influence in this regard. The water supply of northwestern Manitoba and parts of eastern Saskatchewan is largely controlled by the Riding Mountain run-off. The main feeders of the Assiniboine—the Shell, Bird-tail, Little Saskatchewan and Rolling Rivers—here take their rise. Hence come partial supplies also for the well-watered Ochre, Dauphin and Gilbert Plains. The forest stores up the heavy precipitation of winter and spring for use by the stock on the plains during the dry months of late summer and autumn. The farmers along the reserve south of Grandview, for instance, are well acquainted with the truth of this statement.

Use of the Reserve as a Pleasure and Health Resort.

There are many delightful camp sites in the reserve, but the best will be found in the vicinity of Clearwater Lake. The people on the prairies are too busy growing wheat as yet to think much about summer holidays, but with the growth of the towns the leisured class is increasing, and within a few years this charming sheet of water will have its summer colony. The lake is at an altitude of 2,100 feet. Whitefish and pickerel abound. The great drawback at present is the lack of good trails, which must be overcome before campers will enter. It is the aim of the Forestry Branch to make this reserve as popular and extensive as possible.

TABLE XXXIV.—ESTIMATE OF SAW MATERIAL ON THE RIDING MOUNTAIN FOREST RESERVE.

Species.	Board feet.	Per cent.
Aspen.....	85,350,143	41
Balm.....	27,032,691	13
White Spruce.....	42,135,088	20*
Jackpine.....	11,267,500	5
Birch.....	15,172,356	7
Larch.....	9,135,096	4
Black Spruce.....	17,006,112	8
Balsam.....	3,328,000	1.5
Other species.....	.....	.5
Total.....	210,426,986	100.0

* Half on the limits and non-available.

The above estimate is based on timber measurements made in a forest survey of the reserve. The estimate includes all timber eight inches and over in diameter at breast-height.

TABLE XXXV. — LAND CLASSIFICATION OF THE RIDING MOUNTAIN FOREST RESERVE.

(APPROXIMATE STATEMENT.)

	Acres.	Remarks.
Water.....	95,000	25 per cent carrying pole stuff. 80 per cent carrying reproduction.
Swamp and Muskeg.....	140,800	
Brûlé.....	369,600	
Semi-Brûlé.....	51,608	
Prairie and semi-prairie.....	104,073	
Timbered.....	221,319	
Total area.....	982,400	



Clear Lake—an ideal spot for summer campers. The Lake is five miles in length by seven miles in width.
(Photos by R. D. Craig)



Large Moose in Scrub. Taken in valley of Robinson River.

PLATE XVIII.



[Photo by *H. R. MacMillan*.]
A typical slough, the haunt of wild fowl.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000



